PARASITOLOGY AND THE QUEENSLAND MUSEUM WITH BIOGRAPHICAL NOTES ON COLLECTORS

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Queensland and the Queensland Museum have a long association with parasitology beginning with one of the early members of the Board of Directors, Dr Joseph Bancroft, who gave his name to the worm which causes elephantiasis, *Wuchereria bancrofti*. Collections of parasites made during the 19th and 20th centuries, that are now housed at the Queensland Museum, are discussed. Such collections are not uniquely Australian, but include a considerable number of specimens collected in other parts of the world. That the Queensland Museum has become their repository is a testimony to the importance placed on the field of parasitology in Queensland during the past 120 years by medical, veterinary and biological scientists. Their investigations have gained them international recognition for the excellence of their research into the knowledge of a wide range of parasitic organisms. The relevance and context of the Queensland Museum as a repository of whole parasite specimens is discussed. Historical background on the collections and their collectors is provided, and on the influences and motivations of the researchers and the times in which their collections were made. Today the Queensland Museum's parasite collections are amongst the most significant in the world. The growth of the parasitology collections at the Queensland Museum over the last 25 years, and especially during the 1990s is detailed. In December 1995 the collection of the International Reference Centre for Avian Haematozoa (IRCAH), a United Nations sponsored collection of blood parasites of birds, was placed under the Queensland Museum's stewardship. ❐ *parasitology, history, Nineteenth Century, Twentieth Century, Queensland, biography, collections*

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This monograph is an historical commentary on the growth and study of parasitology in Queensland, the stories of the parasitologists themselves, and how and why they acquired the collections that now form the core of the Queensland Museum parasite holdings. Lists of species, museum accession numbers, and details of the coverage and magnitude of these collections, are available from the Queensland Museum upon request.

In biology the predictability and therefore the stability of science is vested in the authority of the names provided to organisms. The names are attached to specimens in museums and thus the work of collection, research on, and long term care (curation) of specimens in museums forms a pillar underpinning all of biology.

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PART A: THE DEVELOPMENT OF PARASITOLOGY IN QUEENSLAND

EARLY PARASITOLOGY IN QUEENSLAND: 1876 TO 1940S

Queensland can justifiably be cited as the 'seat' of parasitology in Australia. With much of the State lying within the dry tropics, Queensland has played 'host' to a number of medical parasites and an even greater number of veterinary parasites, many of which are vector-borne. As a result Queensland investigators have for more than 100 years earned international recognition for their research in entomology as well as in parasitology.

Although the Queensland Museum was established nearly 150 years ago, very few parasite specimens were lodged in the Museum Collections until the early part of the 20th century,

despite a strong research interest in parasitology in Queensland.

THE BANCROFTS

The most illustrious of Queensland's pioneers in medical research is Joseph Bancroft, a practising physician who came to Brisbane in 1864 from Manchester, England (QIMR Annual Report, 1991). One of the former Trustees of the Queensland Museum, Joseph Bancroft (Fig. 1) is 'immortalised' by the fact that the specific name of the causative organism of human filariasis ('elephantiasis') was named in his honour, *Wuchereria bancrofti*. Patrick Manson (1878) was the first to demonstrate that a nematode may undergo an obligate phase of development in an insect vector with his studies of this filarioid worm. In 1877, as a British physician working in Amoy, China, Manson (1878; 1883) carried out his classic studies on 'the female species of the brown household mosquito, of the genus *Culex*'. Wucherer in Bahia, Brazil; Lewis in Calcutta, India and Manson in Amoy, China, had all observed immature forms of this filarioid in the chylous urine of patients prior to Manson's observations of its development to the infective L_3 larval stage in the mosquito (Foster, 1965).

It was Joseph Bancroft in Brisbane who in 1876, found four living adult female filarial worms in the hydrocoele of a patient. On sending these preserved specimens to Thomas Cobbold in London who had previously identified Manson's specimens of the immature forms of the parasite, Bancroft's worms were pronounced by Cobbold to be the mature, adult form (Boreham & Marks, 1986; Mackerras & Marks, 1973). Subsequently, Thomas Lane Bancroft (Fig. 2), son of Joseph Bancroft and himself a physician and fine naturalist, demonstrated that transmission of the pre-larval form of the filarioid, the microfilaria, was via the bite of the mosquito *Culex quinquefasciatus*. Thus the life cycle of human filariasis was completed by these two Queensland medical men. Thomas Bancroft established a fine reputation for his scientific researches with his papers on such diverse parasitological subjects as trypanosomes in rats, a whipworm in rat livers, filariae in birds and *Echinococcus* in the wallaby — all first records in Australia (Mackerras & Marks, 1973). He was, however, a researcher before his time, for there were few research positions available in Australia then although moves were afoot to

FIG. 1. Joseph Bancroft

FIG. 2. Thomas Bancroft

establish an institute dedicated to research into tropical diseases.

THE AUSTRALIAN INSTITUTE OF TROPICAL MEDICINE TOWNSVILLE, QUEENSLAND: 1909–1930

Germane to Australia's — and more specifically Queensland's — establishment of research institutes dedicated to investigating human tropical diseases, is brief mention of Sir Patrick Manson, dubbed 'The Father of Tropical Medicine' (Manson-Bahr, 1962). Manson (1878) was the first person to demonstrate the vector-borne nature of any parasitic disease, with his discovery in 1877 that the filarioid worm we now know as *Wuchereria bancrofti* undergoes an obligate phase of development in a mosquito (see above). Following his return to London in 1890 after many years abroad in China and Hong Kong, Manson in 1897 became Medical Advisor to the Secretary of State for the Colonies. In this capacity, he was instrumental in establishing both The London and The Liverpool Schools of Tropical Medicine in 1899 (Douglas, 1977a). This prompted other countries to establish similar laboratories — a cry taken up in Australia in 1902.

With 40 percent of Australia lying within the 'dry tropics' and much of the rest of Australia being sub-tropical, there was a need to establish an institute specifically dedicated to the study of tropical diseases. A comprehensive record of the series of events leading up to the establishment of such an institution in North Queensland has been documented by Douglas (Douglas, 1977a; 1977b; 1977c) and it is not intended to do more than record important dates cited by

FIG. 3. Australian Institute of Tropical Medicine, Townsville ca. 1912. This building was specifically erected in 1912 to house the AITM because the existing building in which it opened in 1910 proved unsuitable.

him. Lobbying for an 'Australian Institute of Tropical Medicine' was centred in Cairns, North Queensland, although the suggestion was first put forward by a South Australian, Dr Goldsmith, in 1902 who at the time was practising in Darwin. Goldsmith had known Manson well, and was greatly influenced by him (Douglas, 1977a). Subsequently, in 1907, a Melbourne medical graduate R.A. O'Brien, who practiced in Cairns between 1904 and 1910, impressed on the Bishop of North Queensland, Dr Frodsham, the pressing need for an Australian institute for the study of tropical diseases (Douglas, 1977a). The Bishop energetically lobbied for the establishment of such an institute, enlisting the support of Sir Charles Martin, FRS,[1] Director of the Lister Institute in London. O'Brien at one stage had worked with Sir Charles Martin at the Lister Institute, and was himself to become Director of the Wellcome Physiological Research Laboratory London, 1914–1940. Establishment of the Australian Institute for Tropical Medicine (AITM) (Fig. 3) became a reality in 1909 when it was opened by the Governor of Queensland, Sir William McGregor, himself a medical practitioner with a high reputation for his work in tropical countries (Douglas, 1977b). It was the first medical research institute established in Australia, antedating the Walter and Eliza Hall Institute of Medical Research in Melbourne by six years (Cilento, 1962). It is worth digressing here to note that the first research institute dedicated to investigations into disease of any kind in Queensland, was the Queensland Stock Institute (Fig. 4) established in Brisbane by the Queensland Department of Agriculture and Stock in 1893, under the directorship of C.J. Pound (Fig. 5). In the absence of any laboratories to conduct medical research at that time, Pound was called upon to undertake investigations into human disease (Angus, 1998). At Pound's urging, the Queensland government in 1895 built a fine new laboratory in College Road (now College Terrace), Brisbane, to replace the inadequate rented premises in Turbot Street which originally housed the Stock Institute. Although operations of the Stock Institute were transferred to the new buildings with Pound in charge as Government Bacteriologist, the laboratory became known as the Bacteriological Institute (Fig. 6) and its administration was transferred to the Health Division of the Home Secretary's Department. It is important to record that the origin of Queensland's first pathology laboratory was the Queensland Stock Institute, establishment of which had been funded by livestock farmers.

FIG. 4. Queensland Stock Institute, Turbot Street, Brisbane established by Queensland Dep. of Agriculture & Stock in 1893. (Photographed in Brisbane ca. 1953

ANTON BREINL

For a suitable Director of the AITM, the opinion of Sir Charles Martin was sought, along with that of representatives of The Royal Society, and The London, and The Liverpool, Schools of Tropical Medicine. Acting on behalf of the University of Sydney through which institution the appointment was made, Martin wrote in August 1909 to Dr Anton Breinl (Part B, Fig. 51) of the Liverpool School of Tropical Medicine advising him he had been appointed Director of the AITM in Townsville, Queensland (Douglas, 1977a). Breinl was at the time of this appointment, Director of the Runcorn Research Laboratories and Assistant Lecturer at The Liverpool School of Tropical Medicine (QIMR, Archival records, 1909). Breinl was a most worthy choice for this position. A medical graduate of the University of Prague, he had earned his post-graduate certificate in tropical medicine at the Liverpool School of Tropical Medicine and subsequently had been elected as J.W. Garrett International Fellow at the University of Liverpool, 1904–1907 (Douglas, 1977b). During this period he earned international acclaim for his collaborative research with Dr H. Wolferstan Thomas in discovering the efficacy of Atoxyl, a pentavalent organic arsenical, as a curative agent for sleeping sickness. Breinl's research was being closely monitored by the illustrious Paul Ehrlich who gained world renown for formulating Salvarsen, a trivalent arsenical which cured syphilis (Marquardt, 1949). Ehrlich, in his reference supporting Breinl's application for the position of Director of the AITM, hailed him as 'one of the leaders in modern chemotherapeutic work' and also as 'a very prominent investigator' (QIMR records). On taking up the Townsville appointment, Breinl took with him his laboratory assistant, J.W. Fielding who was to write a history of the AITM (Fielding, n.d.) from its beginnings up to the time of its transfer to Sydney in 1930. Fielding remained with the Institute until his death in 1954 (Douglas, 1977b).

TROPICAL DISEASES IN AUSTRALIA IN THE EARLY 20TH CENTURY

Breinl's first concern after taking up appointment on 1st January 1910 was to investigate the diseases then prevalent in Queensland. Benign tertian malaria (*Plasmodium vivax*) was present, as were tropical sprue and typhoid fever. Dengue fever was common and hookworm infestation was prevalent. The presence of the mosquito *Aedes aegypti* concerned him, since it is the vector of yellow fever, a disease which Breinl himself had contracted during a visit to Manaus, Brazil, in 1905 and which left him with facial palsy (Douglas, 1977b). History records that yellow fever had wreaked such havoc amongst labourers building the Panama Canal that its completion was severely delayed (Scott, 1939).

Breinl's preferred option was to prevent, rather than to cure, disease. In 1911 he joined an expedition to the Northern Territory and in 1912,

FIG. 5. C.J. Pound

FIG. 6. Bacteriological Institute, College Road, Brisbane. 1899, built by Qld Dept. of Agriculture & Stock to replace rented premises in Turbot Street

travelled through Papua's coast from Port Moresby through Samarai to the Mambari River bordering German New Guinea, recording the diseases he observed (Douglas, 1977b).

Expansion of the scope of the AITM was favoured by Dr J.S.C. Elkington who had been appointed Commissioner of Public Health for Queensland on 1st January 1910, the same date as Breinl's appointment commenced. His career in this appointment was to become intertwined with that of Breinl's (see below). The AITM Committee of which Elkington was a member, approached the Federal Government for an increased subsidy to fund the building of a new laboratory and an animal house. Scientific staff appointed for the expanded laboratory included a bacteriologist, a biochemist and a parasitologist. As well as conducting research into tropical diseases, much effort was put into identifying parasites of various native and domestic animals and investigating veterinary diseases. During Breinl's directorship of the AITM from 1910 to 1920, he authored or co-authored 22 of the Institute's 57 publications (Douglas, 1977b).

THE RISE AND FALL OF THE AUSTRALIAN INSTITUTE OF TROPICAL MEDICINE

By the advent of the 1914–1918 World War, Breinl had established an Australia-wide reputation for his successful treatment of malaria. He treated servicemen sent to him from the German New Guinea theatre of war and in a voluntary capacity assumed the duties of Superintendent of Townsville General Hospital in addition to carrying out his duties as Director of the AITM. Details of his personal travails as a German-speaking citizen, albeit a naturalised Australian, are contained in his biographical note (Part B), but mention should be made here that despite his demonstrated dedication to medical research added to his performing clinical duties, he was the target of cruel xenophobic prejudices which became intolerable and resulted in his resignation from the AITM in October 1920 to take up private practice in Townsville (Douglas, 1977b).

J.H.L. CUMPSTON

Until March 1921 there was no Commonwealth Health Department, quarantine being the only health activity carried out by the Australian Government. Health had always been regarded as a responsibility of the various state governments (Douglas, 1977b). The 'architect' of the Commonwealth Department of Health was medical graduate J.H.L. Cumpston (Cilento, 1962) who had been recommended by Elkington to control the Commonwealth Sub-Department of Quarantine. He was, in due course, to become Chief of the Commonwealth Quarantine Service (Douglas, 1977c) and it was Cumpston who orchestrated Breinl's downfall (see Part B).

Queensland's Commissioner of Public Health, Dr J.S.C. Elkington, dedicated himself to demonstrating the capacity of the white man to colonise tropical Australia without any detrimental effects on longevity, fertility and physique, for he considered this to be the determining factor in Australia's successful colonisation. Such thinking dominated Queensland medical policy for 20 years (Cilento, 1962). Elkington ensured State control of Public Health and succeeded in wresting the Bacteriological Institute from the Queensland Department of Agriculture and Stock which had been responsible for its foundation (Angus, 1998). Elkington placed it firmly under his control, renaming it the Laboratory of Pathology and Microbiology, and in March 1911 he placed it under the directorship of medically qualified Dr John Harris (Cilento, 1962). Elkington arranged with the Commonwealth Government to carry out quarantine duties concerning ships, persons and goods, and expanded preventative measures such as vaccination in the tropics by arranging the services of health care workers at call. The Queensland State government baulked at the cost of these services in remote areas and terminated its quarantine agreement with the Commonwealth. At the end of 1913, frustrated at his inability to carry out a program of disease prevention, Elkington resigned as Queensland

Commissioner of Public Health and moved to the Commonwealth Government — first as the Chief Quarantine Officer for Queensland and the Northern Territory, and later as Director, Division of Tropical Hygiene. He ensured his ongoing 'control' over the AITM by enlisting the Commonwealth's financial responsibility for the Institute, which was struggling for lack of funds (Cilento, 1962).

Elkington had an enthusiastic vision of a Tropical Medicine Institute at Townsville which would offer training to Australasian and central Pacific Island medical workers, qualifying them for a diploma of tropical medicine. For eight years he put forth proposals for an 'Inland and Island Tropical Medical Service' which would link western and northern Queensland and the Northern Territory with Papua, New Guinea, the Solomon Islands, the New Hebrides and Fiji, for the purposes of collaborative research and training. Strangely, his ideas of a diploma in tropical medicine and hygiene were not supported by the medical schools of Sydney, Melbourne and Adelaide universities (Cilento, 1962). Additionally, the views of J.H.L. Cumpston, by then Director-General of the Commonwealth Department of Health, were to limit the AITM's functions to:

- medical and sociological research for disease prevention and control and investigating factors affecting life in the tropics — especially the physiological effects of tropical habitation by 'the White Race';
- provision of routine laboratory facilities to assist with medical diagnoses and treatment;
- the development of a program giving training towards a diploma in tropical medicine and hygiene.

Despite promising responses from New Guinea and Fiji regarding Elkington's proposal for an Inland and Island Medical Service with a conference of other interested island communities being mooted, no such conference eventuated and Elkington realised that his objective was considered as merely visionary. He resigned in 1928, and this resulted in the immediate liquidation of the tropical program based at the AITM (Cilento, 1962).

The three southern states whose universities boasted medical schools, favoured Commonwealth intervention in the health field. They considered tropical activities based in Queensland, which had no medical school of its own, to be too remote. Immediately following Elkington's resignation in 1928, the Commonwealth government proposed building a School of Public Health within the grounds of Sydney University. This would, in February 1930, absorb the AITM at Townsville, its library, resources and staff, becoming known as The School of Tropical Medicine and Public Health (STMPH) (Cilento, 1962).

In 1987, the AITM was re-established in Townsville by the James Cook University of North Queensland following recommendations of the Kerr White Report of 1986 (James Cook University, 2007: http://www.jcu.edu.au/school/phtmr/abc/). Initially renamed The Tropical Health Surveillance Unit, its mandate encompassed population studies, epidemiology of common disorders, health risks occurring in the tropics, tropical disease vectors and collaboration between health-related groups. In 1988 this name was changed to The Anton Breinl Centre for Tropical Health and Medicine since the University considered it would not undertake a significant role in surveillance and disease control but rather, would concentrate on research and teaching. In November 1992 the Centre became part of the Department of Public Health and Tropical Medicine in acknowledgment of its academic merit, and in 1997 was integrated into the newly formed School of Public Health and Tropical Medicine within the Faculty of Health, Life and Molecular Sciences at James Cook University. In 2002 the Centre underwent yet another name change, becoming known as The Anton Breinl Centre, the name by which it is known today (JCU website, 2007: http://www.jcu.edu.au/school/phtmr/abc/).

T. HARVEY JOHNSTON

Dr T. Harvey Johnston (Fig. 7), who became one of Australia's leading parasitologists, was foundation Professor in Biology at the University of Queensland (Mawson, 1952). Appointed Lecturer in Charge of the Department of Biology at the newly formed University of Queensland, he took up his appointment in June 1911 and was subsequently appointed in 1919 to the Chair of Biology, a position he occupied until accepting the Chair of Zoology at the University of Adelaide in August 1921 (Sandars, 1954). During his time in Queensland, he was consulted on all manner of economic problems including the cattle tick and sheep blowfly. He also made repeated visits to Eidsvold to interact with Thomas Bancroft, who provided Johnston with much important research material (Mackerras & Marks, 1973). When, in 1915, he learned that Thomas Bancroft's daughter

FIG. 7. T. Harvey Johnston, Foundation Professor of Biology at the University of Queensland

Josephine was to join his biology classes as a science student, he was quite excited. Following her graduation in May 1918, Josephine Bancroft was awarded a 2-year Walter and Eliza Hall Institute (WEHI) Fellowship in Economic Biology at the University of Queensland where she worked under Johnston's guidance. Between 1918 and 1921 they co-authored 16 papers with Johnston as senior author, covering both parasitological and entomological topics. They described three new species of *Musca*, the life histories of these and the bush-fly, *Musca vetutissima;* the larvae and pupae of three species of Tabanidae and five species of chalcidoid parasites of Muscidae. Josephine investigated certain Diptera as possible transmitters of *Onchocerca gibsoni* in cattle and habronemiasis in horses. Additionally, she and Johnston described six new sporozoan parasites from freshwater fish and one from a frog (Mackerras & Marks, 1973). Her WEHI Fellowship with Johnston provided her with exceptionally good scientific training as a research worker, for Johnston, in addition to having a wide-ranging knowledge of biology *per se*, was scrupulously exacting in his compilation of data (Sandars, 1954).

During Johnston's Queensland years he trained many students who were to become eminent scientists in their own right, notably Prof. Raymond Dart of anthropological fame whose career flourished at the Department of Anatomy and Anthropology at the University of Witwaterstrand, South Africa, Prof. O.W. Tiegs, FRS, who became Professor of Zoology at the University of Melbourne, Dr Otto Hirshchfeld, one-time Deputy Chancellor of the University of Queensland and after whom the anatomy building is named — and Josephine Bancroft/Mackerras (Sandars, 1954). Although he was able to pursue his wide zoological interests in Queensland and was much appreciated in that State, his decision to apply for the Chair of Zoology at the University of Adelaide may well have been influenced by the fact that Adelaide had a Medical School which, in 1921, the University of Queensland lacked[2]. Being Professor of a department in a university with its own medical school was important to a parasitologist. In Adelaide, Johnston trained a number of parasitologists who contributed greatly to the knowledge of helminthology in particular Madeline Angel (Digenea), Stan Edmunds (Acanthocephala) and Patricia Mawson (nematodes) (see below).

What few type specimens comprise the T. Harvey Johnston Collection at the Queensland Museum, were donated by him in the ten-year period 1911–1921 whilst he was at The University of Queensland.

With Johnston's departure to Adelaide in the early 1920s, research into and teaching of parasitology waned in Queensland. It was not until the re-birth of the Veterinary School at the University of Queensland post-World War II, that parasitology came into its own (see below). From the early 1950s, the field of parasitology became a dominating force of academic and applied research, not only within the University of Queensland, but also in State and Federal government research laboratories.

EARLY ENTOMOLOGY IN QUEENSLAND — ALEXANDRE A. GIRAULT: PARASITIC WASPS

Alexandre Girault's collection of Australian Chalcidoidea (Hymenoptera) is in the care of the Queensland Museum. The Chalcidoidea are parasitic wasps, many of which are useful as natural biocontrol agents for insect pests (CSIRO, 1973).

Dr E.C. Dahms who was the Curator of Higher Insects for 30 years, wrote an unbiased biography

of A.A. Girault (Dahms, 1978). His stated reasons were 'to promote a better understanding of Girault so that through this understanding will grow a greater tolerance and appreciation of his work'. In an effort to provide background on the Collection of Chalcidoidea at the Queensland Museum and of its collector, a précised account of Dahms' comprehensive biography is included in Girault's biographical note (Part B).

Alexandre Arsene Girault (Part B; Fig. 55) was an American entomologist who came to Queensland in 1911 on appointment to the Department of Agriculture and Stock at a salary of £400 p.a. He was assigned to the Queensland Bureau of Sugar Experimental Stations to investigate the life history and habits of the cane beetle (Scarabaeidae), the larval stages of which eat the roots of sugar cane (Dahms, 1978). His speciality was the Hymenoptera, particularly the taxonomy of small parasitic wasps belonging to the superfamily Chalcidoidea. He experienced difficulty in securing permanent appointment as an entomologist, largely due to what Dahms has defined as 'his uncompromising direct nature' which led him and his family into much financial hardship and himself into professional deprivation. Although he collected specimens from 500 Australian localities and published 462 papers including 63 privately published papers, his large monograph on the Australian Chalcidoidea, begun in 1917, remained unfinished at his death (Dahms, 1978). His extensive collection was taxonomically verified or emended by Dahms (see below) who was awarded a Doctor of Science degree by The University of Queensland for this monumental undertaking.

Girault was a dedicated entomologist who described thousands of new chalcid wasps from Australia, but his lack of taxonomic facilities and irregular collaborative interaction with colleagues, often led to taxonomic confusion that has needed subsequent workers, principally Dahms, to clarify.

At the beginning of his curatorship at the Queensland Museum, Dahms found that type specimens of Girault's Hymenoptera, and also of Thysanoptera [thrips] were stored in twelve microscope slide drawers. The slides had been stored without order as to families, genera and species, and in some instances not even an Order was provided. The pinned specimens were tightly packed into nine cabinet drawers. Locating type specimens was thus a very arduous process. Moreover multiple type specimens were routinely mounted on single slides, due to Girault's chronically impecunious state. A grant from the Australian Biological Resources Study (ABRS) allowed Dahms to travel to other institutions, including the US National Museum, to catalogue their holdings of Girault's types of Australian Hymenoptera. Dahms' ultimate aim was to produce a Checklist of the Australian Chalcidoidea described and identified by Girault. The first such Checklist was published in 1978 (Dahms, 1978) with three more to follow (Dahms, 1983, 1984, 1986). A review of encyrtid genera whose type species were described from Australia by A.A. Girault, was compiled in collaboration with Prof. Gordon Gordh, Professor of Entomology, University of Queensland, and published in 1997. It includes generic diagnoses, type species redescriptions, relevant figures and listings of the extant material of the included species (Dahms & Gordh, 1997). Girault is remembered more for his eccentricities than for his tremendous contribution to taxonomy of the Chalcidoidea, a situation which Dahms and subsequently Dahms & Gordh sought to redress. In an excerpt from their Introduction they say:

> 'The most significant contribution to knowledge of Australian encyrtids was made by Girault who described more than 300 nominal species from Australia placed within his own genera. During 1914–1941, Girault proposed 179 generic-level names, 157 of which were described from material collected in Australia [...] Of the 154 genera proposed by Girault, 93 remained monotypic [...] the group in Australia has been taxonomically ignored after Girault. Thus a study of the Australian encyrtid fauna is essentially a study of the fauna as described by Giraultt [...]

The bulk of Girault's collection of Chalcidoidea is housed in the Queensland Museum, and is now listed under the amended generic diagnoses and type species redescriptions given in Dahms & Gordh (1997).

THE ADVENT OF A NEW ERA IN QUEENSLAND STATE HEALTH RESEARCH

In the period 1934–35, there was an outbreak of Weil's disease (the most severe form of leptospirosis[3]) in the canefields of north Queensland. This led to the extension of the laboratory services at the Queensland Department of Health in Brisbane and here, Dr Edward H. Derrick undertook much of the former program of the Australian Institute of Tropical Medicine. Derrick's brilliant investigations included the elucidation of the aetiology of 'Q' fever, a disease affecting abattoir workers, the causative agent of which was named *Rickettsia burnetti* by Derrick (1939), the name being more recently modified to *Coxiella burnetti*.

This disease is of international importance and occurrence. Derrick's research as Director of the Queensland Department of Health's Laboratory of Microbiology and Pathology between 1935 and 1944, included isolation of further types of leptospires, identification of Queensland murine typhus and other diseases (Doherty, 1967).

THE QUEENSLAND INSTITUTE OF MEDICAL RESEARCH

The Queensland Department of Health's *Annual Report* for 1944 carried Derrick's plea for more support for medical research (Derrick, 1944). Cabinet heeded his plea and instructed him to submit proposals towards the establishment of an institute of medical research. Submitted in mid-1945, Derrick's report resulted in the passing by State Parliament of the *Queensland Institute of Medical Research Act* before the end of 1945 (Doherty, 1978a). Its wide-ranging mandate was to carry out 'research into any branch or branches of medical science'. The Queensland Institute of Medical Research (QIMR) was established on 2 June 1947, and housed in temporary premises in the form of a hut (Fig. 8) purchased from the American Army and located in Victoria Park, Brisbane (QIMR Annual Report, 1990–1991). It was to function in those 'temporary' premises for three decades, during which time research focussed on vector-borne and other viral, parasitic and rickettsial diseases (Kidson, 1985). It was given a new home, The Bancroft Centre, in 1991 (Fig. 9).

IAN & JOSEPHINE MACKERRAS

The first Director of QIMR was Dr Ian Murray Mackerras (Fig. 10), a returned serviceman of both World War I and World War II and a medical graduate of the University of Sydney with First Class Honours in Zoology (Spratt, 1980). In 1924 he married fellow medical graduate Josephine Bancroft, grand-daughter of Joseph Bancroft after whom *Wuchereria bancrofti* was named, and daughter of Thomas Bancroft (see above). Between 1928 and 1939, Ian Mackerras was Senior Entomologist within the Division of Entomology, of the Council for Scientific and Industrial Research (CSIR), in Canberra. Josephine Mackerras also joined CSIR in the same year, as Junior Entomologist (Archives, CSIRO, 26 October 1928). (CSIR subsequently became the Commonwealth Scientific and Industrial Research Organisation, CSIRO).

Ian Mackerras joined the Australian Military Forces (AMF) at the outbreak of World War II, as Captain. He became pathologist to the First Australian General Hospital in Egypt with the rank of Major (Archives, CSIRO, 28 February 1940). In 1942 Papua New Guinea became a theatre of war, and malaria, dengue fever and scrub typhus began to have serious effects on Australian troops

FIG. 8.Queensland Institute of Medical Research's original premises located in Victoria Park, Brisbane, ca. 1947. These temporary premises were utilised for 3 decades.

(Marks, 1991). Ian Mackerras was promoted to Lieutenant-Colonel in 1943, and became Director of Entomology at Land Headquarters (LHQ), Melbourne. LHQ's Medical Research Unit was established in Cairns under the command of Brigadier Neil Hamilton Fairly, to carry out investigations into the drug treatment of malaria (Mackerras & Roberts, 1947). Assessment of drug treatment, in conjunction with entomological work, was planned by Lt.-Col. Mackerras and implemented by his wife, Major Josephine Mackerras (Figs 11, 55) (Mackerras & Marks, 1973), who had joined the Australian Imperial Forces in June 1940 (Archives, CSIRO, 23 May 1940). When both Ian and Josephine Mackerras were discharged in February 1946 (Archives, CSIRO, 25 February 1946) they returned to CSIR, Canberra, in March of that year. Both scientists were subsequently appointed to the CSIR laboratory at Yeerongpilly, in Brisbane, in April 1946 (Archives, CSIRO, 9 May 1946). In March 1947, Ian Mackerras accepted appointment as Director of the newly established QIMR, with Josephine being appointed Senior Parasitologist at QIMR on 1 September 1947 (Mackerras & Marks, 1973).

FIG. 9. QIMR today - The Bancroft Centre, opened in 1991.

M. JOSEPHINE MACKERRAS

On arrival at QIMR, Ian and Josephine Mackerras defined a program to survey the extent of parasitic infection in man in Queensland and to improve methods of diagnosis and treatment. They also set about accumulating knowledge of parasites in native animals which may prove important to man (Doherty, 1978a). During the 14 years that Ian was Director of QIMR, he and Josephine collaborated on a number of entomological and parasitological research projects, 18 of their 24 joint papers being published during this period (Spratt, 1980).

As a youth, Josephine was introduced to natural history by her father, Thomas Bancroft, and assisted him in catching and packaging zoological specimens for the Queensland Museum (Mackerras & Marks, 1973). Thus she was trained early in the importance of well documented specimens for museum scientific collections. Her most significant contributions to the Queensland Museum were those related to her major interests — protozoans, worms and entomology (Cannon, 1996).

In Josephine's classic papers on the haematozoa of all Australian vertebrates (Mackerras, 1959; 1961), she identified eight new species of haematozoa in marsupials and in a monotreme (Mackerras, 1959) and 18 new species of haematozoa from Australian reptiles (Mackerras, 1961). Her research led to significant collections of these organisms being lodged with the Queensland Museum. They comprise the largest such collections in Australia, the only other collection of protozoa being in the Australian Museum in Sydney (less than ca. 100 specimen lots). According to Cannon (1996), the presence of Josephine Mackerras' 'seed collection' played an important role in attracting the donation of the International Reference Centre for Avian Haematozoa to the Queensland Museum in 1995 (see below).

During World War II Josephine's malaria research activities in Cairns included collaborative work with Major F.H.S. Roberts, one of Australia's leading entomologists/parasitologists.

F.H.S. ROBERTS

Frederick Hugh Sherston ('Ozzie') Roberts (Fig. 11) was a biologist in the broad sense. Graduating from The University of Queensland in 1923 with a Bachelor of Science degree with Honours in Biology, his early career (1923–1930) was spent working with the Commonwealth Prickly Pear Board[4]. He became increasingly

FIG. 10. Lt. Colonel Ian Mackerras, Director of Entomology in the Australian Military Forces' Land Headquarters, Melbourne during World War II. Pictured here with Dr. John. Tonge at the LHQ's Medical Research Unit in Cairns, North Queensland (Courtesy Mrs Rosemary Adams, Bilgola Plateau, NSW.)

interested in ecto- and endo-parasites of livestock during that time, and in 1930 was recruited by the Queensland Department of Agriculture and Stock as their first veterinary entomologist, appointed to work at the Animal Health Station (later to become the Animal Research Institute) at Yeerongpilly. His position was altered to that of entomologist and parasitologist in 1936. In 1938, at the bidding of the then Queensland Minister for Agriculture, F.W. Bulcock (1932–1942), Roberts was sent overseas for eight months to study the control of parasitic diseases of livestock in the USA, Canada, Great Britain, Holland, France and South Africa. In 1940 his position was designated 'Parasitologist' (Skerman, 1998). His combined interests in ecto- and endo-parasites are reflected in his finely illustrated book, *Insects Affecting Livestock* (Roberts, 1952), which became a standard text for students and research workers.

In December 1941, Roberts enlisted in the Australian Army (Archives, CSIRO, 10 January 1947), attaining the rank of Major and Commanding Officer of the 2nd Mobile Entomological Unit (Anon., 1972) and carrying out investigations into malaria in both New Guinea and in Cairns. During his time based at the Land Headquarters' Medical

FIG. 11. Major M. Josephine Mackerras, Land Headquarters Medical Research Unit, Cairns. On her right is Major F.H.S. Roberts. (Reproduced with permission of Army History Unit, Department of Defence, Canberra, A.C.T. 9 July 1999)

Research Unit in Cairns he studied the biology of anopheline mosquitoes and collaborated with Major Josephine Mackerras on experimental transmission of malaria (Mackerras & Roberts, 1947).

Following his discharge from the Australian Army in May 1945, Roberts returned to the Department of Agriculture and Stock as Acting Director of Research in the Division of Animal Industry (Archives, CSIRO, 10 January 1947). In March 1947, he accepted appointment as Principal Research Officer in charge of CSIR's[5] newly created Veterinary Parasitology Laboratory at Yeerongpilly (Archives, CSIRO, 28 March 1947).

As his bibliography reflects, Roberts' research included many studies of endo-parasites as well as of ecto-parasites, but he is perhaps best remembered as the author of a definitive text on Australian ticks (Roberts, 1970), a culmination of his taxonomic and biological studies on ticks over thirty years. Prior to the 1940s few tick collections had been made and their systematics was poorly understood (Roberts, 1970). Roberts confined his published records to those species of ticks occurring on the Australian mainland and in Tasmania. Altogether he described three new species of ticks within the family Argasidae (see Halliday, 1998), and 14 new species plus four new sub-species within the family *Ixodidae*.

Holotypes of all these new species and sub-species are held at the Queensland Museum, with the exception of holotypes for *Ixodes antechini* and *I. trichosuri* (Australian Museum); *Ixodes cornuatus* (Museum of Victoria) and

Haemaphysalis lagostrophi (Western Australian Museum).

Roberts' book on Australian ticks is scheduled soon to be revised by tick specialists under an initiative of the Australian Society for Parasitology. In addition to an update of Australian ticks, the revised edition will include a specialist volume containing information on the ticks of Australasia, the Pacific and Southeast Asia, together with a multi-authored, interactive CD-ROM.

Until 1999, the main F.H.S. Roberts Tick Collection was curated by the late Dr David Kemp, a tick physiologist at the CSIRO Long Pocket Laboratories (LPL) at Indooroopilly, Queensland. With the closure of LPL's Division of Animal Production during 1999, the F.H.S. Roberts Tick Collection was sent to the South Australian Museum for cataloguing and curation. It was proposed to be returned to Queensland, to the Queensland Museum but it now seems increasingly likely it will remain in South Australia. Additional material has been added to the F.H.S. Roberts Collection during the past thirty years by Kemp, such specimen's eode numbers in the database bearing the prefix 'K'.

PARASITOLOGY IN THE ASCENDANT IN QUEENSLAND — 1930s to 1986

The mid-1930s ushered in a new era in veterinary parasitology research in Queensland. The initiative taken by the Queensland Department of Agriculture and Stock in 1893 in founding Australia's first institute dedicated to research into diseases of livestock was an influential factor in the government's decision to establish a Faculty of Veterinary Science at the University of Queensland in 1936. The first CSIRO scientist to come to Queensland was appointed to work in Brisbane in 1940 on matters of veterinary concern. Following World War II, the importance of veterinary parasitology in Queensland was acknowledged with the appointment to the Veterinary School of a senior lecturer in parasitology — a research veterinarian who was to establish the first Department of Parasitology in any Australian university.

A VETERINARY SCHOOL FOR QUEENSLAND

The impact of bovine tick fever on the cattle industry in Queensland with its attendant loss to production meant that much of the new Queensland Stock Institute's focus was for many years on the control of that disease and of its tick vector (Angus, 1998). Tick fever was one of a number of veterinary parasitic diseases present in Australia and CSIR in 1930 founded its Division of Animal Health (CSIR Annual Report, 1930), its Division of Animal Nutrition having been created the year before. Recognition by a research organisation for formal research to be carried out in these two areas of the pastoral industry, highlighted the need for Australia to train its own veterinary scientists. The private veterinary school opened in Melbourne in 1888 by W.T. Kendall[6] had become part of the University of Melbourne in 1908, but for various reasons closed in 1927. The Faculty of Veterinary Science established in 1909 at the University of Sydney (University of Sydney Calendar, 1910) was, in 1930, the only veterinary school in Australia. Additionally, Queensland's tropical and sub-tropical climate dictated the need for specific training in line with veterinary diseases occurring in that State. Queensland investigators had already established a fine reputation for applied research into and control of veterinary disease and had led Australia in being the first to establish a laboratory dedicated to research into diseases of livestock — the Queensland Stock Institute (Fig. 4) (Angus, 1998).

The Queensland government recognised the need for veterinary training in Queensland and in 1936, the Faculty of Veterinary Science was inaugurated at the University of Queensland with Dr Harold R. Seddon appointed Professor and Dean (English, 1986). Seddon was concurrently appointed as Advisor to the Queensland Department of Agriculture and Stock and in June 1940 was gazetted as Director of Veterinary Services in that Department (Queensland State Archives, 1947). Since the State of Queensland's livestock research and control centred on the Animal Health Station[7] at Yeerongpilly, it was the obvious site to locate the new Veterinary School. Buildings erected for the Veterinary School at Yeerongpilly were entirely independent of the Animal Health Station. The first building (Fig. 12) was occupied in 1938 (Francis, 1961). Regrettably, the advent of World War II and the enlistment of staff and students in the armed forces led to closure of the Veterinary School in 1943 (English, 1986). It was not until March 1946 that it re-opened for teaching of the first three years of the five-year course — fourth and fifth year students attending Sydney University's Vet School for their two final years of study until 1953 (English, 1986). In the interim, since closure of the Queensland Veterinary School, the main

FIG. 12. Veterinary School building at Yeerongpilly, now A Block of the Animal Research Institute, Queensland Department of Primary Industry. (Animal Research Institute historical material).

new Veterinary Science building had become the Pathology Branch of the Queensland Department of Agriculture and Stock. In its stead, a collection of wooden single story buildings (Fig. 13) was allocated to serve the Veterinary School until its relocation to St Lucia in 1961 (Hoyte, 1990).

THE EARLY BEGINNINGS OF CSIRO IN QUEENSLAND

By 1940, concerns expressed by livestock owners as to the residual effects of the arsenical cattle dip (the 'Queensland dip') on cattle, prompted the appointment of the first CSIR staff member to Queensland. This scientist was Leith Hitchcock (CSIRO Archives, 31 May 1940), an organic chemist who had previously spent 18 years working in North and South America for the Commonwealth Prickly Pear Board in a quest to find bio-control agents to rid Australia of the prickly pear (CSIRO Archives, 1940). He was thus well versed in entomology as well as in chemistry and was appointed to CSIR's Division of Economic Entomology in Brisbane on 23 November 1940 (CSIRO Archives, 1940). His laboratory space was provided in the new Veterinary School building at Yeerongpilly (CSIRO Archives, 22 November 1940). Hitchcock's brief was to investigate arsenic toxicity in cattle as a result of dipping in 'the Queensland dip'. Thus by 1940, the Animal Health Station at Yeerongpilly was home to not only the staff of the Queensland Department of Agriculture and Stock, but the Queensland Veterinary School, and the nascent CSIRO in Queensland (with the newly appointed Leith Hictchcock). CSIR's staff at Yeerongpilly increased to two persons in 1943 with the appointment of organic chemist W.J. Roulston (CSIRO Archives, 10 June 1943).

The post-World War II era saw an expansion of all three institutions at Yeerongpilly. The Animal Health Station came under a newly created Division of Animal Industry, with returned Army officer Dr John Legg being appointed in May 1945 as Acting Director of the new Division, such appointment being confirmed to that of Director of Research within the Division in 1948 (Skerman, Fisher & Lloyd, 1988). Also to return from active service was Major F.H.S. Roberts (see above), who in May 1945 was appointed Acting Director of Research (Animal Industry) (Queensland State Archives, 1947). However

when in early 1948 this appointment had still not been confirmed, Roberts accepted the position of Officer-in-Charge of the new CSIR Veterinary Parasitology Laboratory at Yeerongpilly, under the Division of Animal Health (CSIRO, 1948). This laboratory replaced the erstwhile Veterinary Entomology Laboratory under the Division of Economic Entomology.

The re-born Veterinary School's new Dean and Professor of Animal Husbandry, Dr T.K. Ewer, arrived from Cambridge in 1950 (English, 1986). Lectures in parasitology were initially carried out by Dr F.H.S. Roberts and P.H. Durie of CSIRO, with practical classes being conducted by P.J. O'Sullivan of the Animal Research Institute. However, Parasitology was a core subject in veterinary science and there was a need to appoint a full-time senior lecturer in parasitology. Appointed to this position in March 1952 was Dr J.F.A. Sprent (see below), a veterinarian and zoologist with a doctoral degree from the University of London. At the time of appointment, he was a Senior Research Fellow at the Ontario Research Foundation in Toronto, with a conjoint appointment as Assistant Professor in the School of Hygiene at the University of Toronto (Fallis,1993a). His appointment to the University of Queensland Veterinary School was to result in the subsequent establishment of the first autonomous Department of Parasitology in an Australian university. It became a dynamic research centre in branches of parasitology that included medical as well as veterinary parasites, parasites of wildlife and of marine organisms, and the taxonomy, ecology, and immunology of these parasites. During its 40 years of existence, the Department of Parasitology at the University of Queensland gained international renown as a centre of excellence.

FIG. 13. One of the wooden huts allocated for occupancy by Veterinary School post-World War II. (Courtesy Professor J.C. Pearson).

Sprent's association with the Ontario Research Foundation at Toronto between 1947 and 1952 also had a far-reaching influence over the Queensland School of Parasitology.

THE ONTARIO RESEARCH FOUNDATION, AND THE TORONTO SCHOOL OF PARASITOLOGY

Dr Lester R.G. Cannon likes to refer to 'the symbiotic web' of hosts and parasites within which most organisms are enmeshed. This term might also be applied appropriately to the interaction of the scientists who have passed through the Ontario Research Foundation (ORF) (Fig. 14). Some of the philosophies with which those scientists were imbued have been passed on to students studying in the Department of Parasitology at the University of Queensland by staff and students who were influenced by the ORF — to whit, Prof. John C. Pearson, Dr Lester R.G. Cannon and Dr David Spratt.

It is necessary to provide background on ORF and those who directed it, in order to acquire some understanding of the philosophies that influenced its development and which moulded the thinking of its graduates.

When one thinks of parasites, one automatically thinks of tropical and sub-tropical countries rather than temperate ones, but parasites abound in cold climates too. In Canada, naturalists had been writing of parasites since the mid-19th century and indeed, human malaria was a very real problem in Ontario at that time (Fallis, 1993a). Considerable attention was focussed on parasites of wild animals (which served as reservoirs of infection for domestic livestock), and consequently the Ontario Veterinary College was established in Toronto in 1862, with limited instruction to be given in parasitology. Such instruction expanded in 1908 when the College became part of the University of Toronto, but it was not until 1930 that the Veterinary College had a separate Department of Parasitology. This was the first Department of Parasitology in Canada (Fallis, 1993a).

Two years earlier, in 1928, the Ontario Research Foundation had been established by an Act of the provincial government. It was, however, independent of government having its own Board of Governors. ORF's Director for the first thirty years (1928–1958) was Dr H.B. Speakman who established harmonious relationships with the University of Toronto and who initiated research on parasites at the 'Foundation', as ORF became

FIG. 14. Watercolour sketch of the Ontario Research Foundation painted by R.C. Anderson's uncle. (Courtesy Professor John C. Pearson).

FIG. 15. School of Hygiene, University of Toronto.

known. In 1929 a Department of Veterinary Science was established within the Foundation. Appointed Director of this new Department of Veterinary Science in 1929 was Dr Seymour Hadwen (Fallis, 1993a). Prior to taking up appointment in Toronto, Hadwen was working with G.H.F. Nuttall in Britain, one of their research projects having been chemotherapeutic treatment of piroplasmosis in dogs (Nuttall & Hadwen, 1909a) and in cattle (Nuttall & Hadwen, 1909b), and Hadwen was keen to begin studies of parasites in Toronto. In 1932 Hadwen awarded the Fellowship to study parasites of livestock to A. Murray Fallis, (Part B; Fig. 54), an Honours graduate of the University of Toronto (Fallis, 1993b).

A. MURRAY FALLIS

(At ORF 1932–1966, and from 1966–1975, at the Department of Parasitology, School of Hygiene, University of Toronto). Fallis enrolled in the Department of Zoology under the supervision of Dr E.M. Walker (Anderson, 1986), and all of Murray Fallis' research was undertaken at ORF (Craigie, 1965). Graduating PhD in 1937, Fallis was in 1938 invited to teach medical parasitology to physicians proceeding to a Diploma of Public Health in the School of Hygiene University of Toronto (Fig. 15). The School of Hygiene had been built in Toronto in 1927 with funds from the Rockefeller Foundation, and its curriculum from the outset included lectures on parasitology (Fallis, 1993a). Emphasis on parasitology in medical curricula in North America increased during World War II because of its importance to human health. Fallis obtained some field experience in Central America in 1942, and in 1944 a sub-department of parasitology was established in the Department of Hygiene and Preventive Medicine which became a full Department in 1952 (Craigie, 1965). This interaction between ORF and the Department of Hygiene and Preventive Medicine was of added significance in that classical studies of the life cycles of some parasites of wildlife carried out by graduate students and staff of ORF had direct application in identifying zoonotic infections in humans (see below).

The Department of Veterinary Science at ORF underwent various changes in name to become the Department of Parasitology in 1947, since most research in the department by then dealt with parasites. Hadwen retired in 1947 and Fallis became head of the Department of Parasitology at ORF until it was integrated with the School of Hygiene in 1966 (Anderson, 1986). Following the integration, Fallis became Chairman of the Department of Parasitology until 1975 (Fallis, 1993b) having achieved international recognition for his studies on avian haematozoa. His career is more fully discussed in Part B.

One topic of research undertaken at ORF in 1947 was the cellular immunity associated with infection of pigs by the large roundworm *Ascaris suum*. Quite fortuitously, in the summer of 1947, Dr Murray Fallis met Dr J.F.A. Sprent in Chicago at the conference of the American Society for Parasitology.

JOHN F.A. SPRENT

(At ORF 1948–1952). In 1947 Sprent (Fig. 16) was a Research Fellow at the University of Chicago working with Dr W.H. Taliaferro. Taliaferro's initial interest in studies of the immunology of *Ascaris* had to be curtailed due to his developing acute sensitivities to allergens in the cuticle of *Ascaris* spp. (Sprent, pers. comm.). Sprent became

FIG. 16. A, J.F.A. Sprent Research Fellow at the University of Chicago, 1946. B, Outside research hut, Lake Sasejewun, Algonquin Park, Ontario. ca. 1948. (Photographs 16a; b all by courtesy Professor J.F.A. Sprent).

particularly interested in the work of José Oliver-Gonzalez who had found the component tissues of *Ascaris suum* contained agglutinogenic factors. To find which tissues contained antigen functional in promoting resistance to infection, Sprent decided to study the host-parasite immunological response of *Ascaris* (Sprent & Chen, 1949a, b; 1950), although it meant removing himself to a building distant from Taliaferro's laboratory. In 1947 Sprent met Prof. Murray Fallis at the American Society of Parasitology Conference in Chicago (Fallis, 1993a). Fallis was at that time Head of the Parasitology Department of the Ontario Research Foundation and he invited Sprent to apply for a position at the Foundation. Following this meeting Sprent was appointed to ORF in 1948, as Senior Research Fellow with a conjoint appointment as Assistant Professor in the School of Hygiene at the University of Toronto (Fallis, 1993a). An increasing number of graduate students were at that time applying to the University of Toronto to work in parasitology, and Sprent lectured under-graduates and supervised post-graduate students at the university, in addition to expanding the studies begun at ORF on the immunology of *Ascaris* (Sprent, 1950a, b; 1951b). Details of Sprent's research at ORF are included in his biographical note.

In 1952 Sprent resigned from ORF in order to take up appointment at the re-born Veterinary School at the University of Queensland (Sprent, 1952a). Appointed to ORF as his successor was Dr Reino ('Ray') S. Freeman (Fallis, 1993a) (see below).

Much of Sprent's research in Ontario was carried out at the Wildlife Research Station at Lake Sasajewan in Algonquin Park (Fig. 16b), which was opened in 1938 (Fallis,1993a). Indeed, other scientists and graduate students at ORF who have carried out research at Algonquin Park include John C. Pearson, Gordon F. Bennett, Roy C. Anderson, David M. Spratt and Lester R.G. Cannon.

JOHN C. PEARSON

(At ORF 1947–1955). John Pearson began as a student at ORF during the 1940s, graduating BA (Honours) in 1950 and MA in 1951. He then enrolled for a PhD program of study with Prof. Murray Fallis, according to whom Pearson is one of the few Canadian parasitologists who decided, while receiving his secondary education at the University of Toronto Schools, that he would like to become a parasitologist (Fallis, 1993a).

Pearson's association with ORF began as an undergraduate and continued on as a graduate student. Here he investigated 'swimmers' itch' or cercarial dermatitis occurring offshore along several beaches in the province, his studies beginning in the summer of 1949 between his third and fourth undergraduate years. He also carried out classical research on the life cycle of *Alaria canis* and *A. arisaemoides* in foxes, observing that the mesocercariae of the worm disappear immediately on contact with the eye of a frog, which was the host for the next stage of the parasite. Pearson demonstrated, as others had done for other species of *Alaria*, that mesocercariae developed in tadpoles and could survive unchanged in the tissues of animals other than the canids in which they developed into adults. Thus, humans as frog-eating animals, can acquire mesocercariae in our tissues via penetration through the viscera. Twenty-five years later these observations were useful to Dr Michael O'Shea, Head of the Department of Ophthalmology at St Michael's Hospital in Toronto, who discovered a living parasite on the retina of a patient's eye. Morphologically, the parasite resembled the mesocercarial stage of an *Alaria* species, described by Pearson as occurring frogs. Pearson had shown the living mesocercariae to his unofficial supervisor, Ray Freeman during his student days, and Freeman recognised and identified those presented to him by O'Shea, as belonging to a species of *Alaria*. O'Shea's patient was known to have prepared frogs' legs for her family to eat. This was the first record of a zoonotic infection with the *Alaria* parasite (subsequently destroyed by O'Shea with a laser beam)(Fallis, 1993a). In publications relating to intraretinal larval trematode infection (O'Shea *et al.*, 1973a, b, c; Fallis *et al.*, 1973) it was reported that these mesocercaria can penetrate the cornea in less than 24 hours. O'Shea utilised other ORF research in identifying a human ocular infection with a canine tapeworm (O'Shea *et al.*, 1973c) (see below).

During his studies at ORF, Pearson became friendly with J.F.A. Sprent who was impressed with Pearson's scientific competence. This friendship was to result in Pearson's being appointed in 1956 as the first post-doctoral Fellow (Helminthology) (Fig. 17), in the then Department of Anatomy and Parasitology at the University of Queensland Veterinary School. Pearson went on to establish an international reputation as a trematodologist during his lifelong career at the University of Queensland, culminating in the award of a Personal Chair in Helminthology.

A student working as a graduate student and research assistant at the Algonquin Park Research Station during Pearson's years at ORF was Gordon F. Bennett.

GORDON F. BENNETT

(At ORF 1949–1966). In 1949 Gordon Bennett (Fig. 18) enrolled in science at the University of Toronto with the intention of specialising in Zoology. However he was advised by one of his professors, Prof. A.F. Coventry, to apply to work with Dr Murray Fallis. Dr Murray Fallis was in charge of a research program at Algonquin Park Research Station where investigations on malaria-like parasites of birds had been ongoing since the Station's opening in 1938. Prof Coventry considered that Bennett's early life in India, with its repeated bouts of malaria, gave him a familiarity with parasites which might indeed determine his future career (Fallis, 1993a).

To finance his post-graduate studies, Bennett was appointed as a research assistant at Algonquin Park. His work during his first summer at the Station included obtaining, staining and examining blood smears from birds. Additionally, through his observations of blackflies' feeding behaviour, Bennett helped identify *Simulium rugglesi* as the vector of *Leucocytozoon simondi*, an infection

FIG. 17. John C. Pearson, Post-doctoral Fellow in Helminthology in the Department of Anatomy and Parasitology, University of Queensland Veterinary School, Yeerongpilly. Pictured outside one of the Veterinary School laboratory huts. ca. 1957 (Courtesy Professor J.C. Pearson).

FIG. 18. Gordon F. Bennett taking blood samples from birds in Algonquin Park, Ontario.

FIG 19. Prof Roy Anderson (Courtesy of Dr D. Spratt).

causing morbidity and mortality in ducks. This fly frequents treetops close to the water's edge of lakes and rivers and feeds on ducks swimming on the water's surface. Such behaviour was in contrast to that of *Simulium venustum*, a forest canopy dweller and another ornithophilic species that was attracted to birds such as the ruffled grouse that live in the forest canopy. Ruffled grouse become infected with *Leucocytozoon bonasae* transmitted by *Simulium venustum*.

Bennett's career is detailed in Part B, but it is important to record here that his duties as research assistant at ORF provided him with experience in working with haematozoa and their vectors — blackflies, biting midges and mosquitoes. Bennett received his MSc in 1954 and proceeded to doctoral studies at the University of Toronto whilst continuing his association with ORF. On completion of his PhD in 1957 he became a staff member of ORF, where he remained until 1966. During that time he worked on species of haematozoa of the genera *Leucocytozoon, Haemoproteus* and *Trypanosoma* and their respective vectors.

Research in parasitology at ORF ceased in 1966 following the transfer of ORF's Department of Parasitology, to the Department of Parasitology in the School of Hygiene at the University of Toronto (Fallis, 1993a). Bennett, who believed the Department of Parasitology should have remained at ORF, accepted an appointment as a Senior Scientist at CSIRO's Laboratories in Brisbane between 1966 and 1968 (Fallis, 1993b), first at Yeerongpilly and then at Long Pocket. Here he worked with Dr Rodger Tatchell on the cattle tick. Bennett subsequently accepted appointment to Memorial University at St John's, Newfoundland, and in this capacity he became Director of the World Health Organisation's International Reference Centre for Avian Haematozoa (IRCAH) (see below).

Another scientist working at Algonquin Park Research Station during Bennett's time there was Roy C. Anderson.

ROY C. ANDERSON

(At ORF 1948–1966). Roy Anderson (Fig. 19) was a graduate of the University of Alberta and became a graduate student and Research Fellow at the University of Toronto, later joining the staff of ORF. Anderson specialised in the parasites of wild animals, and he early-on became recognised as an authority on parasitic nematodes. His original research on filariid nematodes revealed new species and transmission

by blackflies. His assistance was sought by Bennett and co-worker D. Davies in identifying nematodes found at autopsy on the meninges of the brains of many wild animals (Fallis, 1993a). When the brain of an autopsied moose revealed the presence of similar nematodes, Anderson postulated they may be the causative agent of 'moose paralysis'. He appointed his first graduate student, David M. Spratt, to conduct an in-depth study on this topic (see below).

Spratt glowingly described Anderson as 'the only person whom I've observed sit down and write an entire manuscript in longhand and have that published as a paper with barely a change to the original draft' (Spratt, pers. comm.).

In 1966 Anderson was appointed to the Department of Zoology at the University of Guelph, where, in addition to being recognised for his expertise on the life cycles of various filariids and the meningeal worms in cervids, his research included work on the kidney worm in mink, descriptions of several new species, and the preparation of keys to several groups of nematodes. He is the author of a definitive text on nematodes (Anderson, 1992). In 1976 Anderson was appointed Chairman of the Department of Zoology at the University of Guelph, Ontario, and continued in this capacity until his retirement in 1991 (Fallis, 1993a). He died in August 2001 aged 76.

DAVID M. SPRATT

(At ORF 1965–1966). David Spratt (Fig. 20) is a science graduate of the University of Toronto who majored in biology. Initially he embarked on a Masters program at the Wildlife Research Station in Algonquin Park, Ontario with wolf biologist Dr Douglas Pimlott, studying the interaction of timber wolves and white-tailed deer. He decided to switch his project to parasitology in order to work with Murray Fallis' group from the Ontario Research Foundation, among whose members conducting research in Algonquin Park was Roy Anderson studying the meningeal worm of the deer and moose. Anderson had identified this nematode as the cervid lungworm *Pneumostrongylus tenuis* (now *Paraelaphostrongylus tenuis*) which was ingested in larval form along with the snail or slug intermediate host by grazing cervids. In order to determine how this worm reached the central nervous system (CNS) of cervids, Anderson successfully infected guinea pigs with *P. tenuis*. He appointed David Spratt as his first graduate student to carry out a Masters program studying the pathological effects of *P. tenuis* in experimentally infected guinea pigs, haematological changes during the course of infection, and the route of ingested larvae to the CNS (Spratt & Anderson, 1968). In 1966 the University of Toronto awarded Spratt his MSc degree for this work (Spratt, 1966). Spratt had found that these nematodes are responsible for paralysis in moose but are relatively harmless in deer[8].

During the final months of Spratt's MSc studies, John Pearson returned to ORF on sabbatical from the Department of Parasitology, University of Queensland. Spratt vividly remembered meeting this deeply tanned visitor who arrived in the ORF lab on a bitterly cold morning in February 1966, and who brewed in his own pewter pot the strongest coffee Spratt had ever encountered (Spratt, pers. comm.). On hearing that Spratt hoped to further his studies in wildlife parasitology in either East Africa, South America, or Australia, Pearson advised him that there were two research fellowships currently available in the Department of Parasitology at the University of Queensland — one concerning infection with filarioid nematodes of man or animals in Queensland and New Guinea, the other on the ecology and population dynamics of the cattle tick *Boophilus microplus*. The filarioid study was funded by money from the World Health Organisation and the Australian Universities' Commission Research Grant. On application, Spratt was awarded the Fellowship for the study of filarioid nematodes under the supervision of Prof. J.F.A. Sprent.

This study was initiated along two lines. Firstly, a survey of filarioids was undertaken in native and domestic animals (Lavers, Spratt & Thomas 1969; Moorhouse & Spratt, 1969; Spratt, Mallett, Derringrton & Thomas, 1971; Spratt & Moorhouse, 1971), preparatory to life history studies on species suspected of being transmissible to man. Secondly, techniques necessary for these studies were developed, and investigations made into the potential insect vectors. Certain human diseases of unknown aetiology were being reported by medical officers and practitioners in Queensland and were suspected to result from migrating larvae inoculated by mosquitoes. Kangaroos were commonly infected with a filarioid which occurred under the skin, this filarioid having been redescribed as *Dirofilaria roemeri* comb. nov., by Roy Anderson in Toronto. Kangaroos occurred in large numbers in Queensland and one disease characterised by a remarkable rapidly spreading skin lesion, had

Fig. 20. David M. Spratt, ca. 1998.

been described by practitioners from the district of Yeppoon in central Queensland.

For his doctoral studies, Spratt concentrated on the infection of macropodids by the filarioid *Dirofilaria roemeri* (see Spratt, 1972a) and its epidemiology (Spratt, 1974). The vectors of *D. roemeri* were shown to be at least 11 species of tabanid fly (Spratt, 1970a, b; 1972a, b; 1974), and the normal host was the eastern wallaroo *Macropus robustus* (see Spratt, 1975). This worm is now known as *Pelictus roemeri* (see Bartlett & Greiner, 1986).

Spratt recounts that he moved from Toronto to Brisbane for a brief doctoral study of three years. Awarded his PhD in 1970 (Spratt, 1970b), Spratt has spent his entire career in Australia. He ended his career as Senior Principal Research Scientist in the CSIRO Division of Wildlife & Ecology in Canberra where he was Leader of the Project: 'Indicators for measuring and monitoring biodiversity and ecological sustainability'. He is the author of 90 publications, 28 of which are single author papers. In 1994 he was appointed Chairman of the Editorial Advisory Committee of the journal, *Wildlife Research*. He retired in 2000, but maintains an active interest in parasitology and wildlife.

On the resignation of J.F.A. Sprent from ORF, Fallis was to appoint another helminthologist, Dr R.S. Freeman, to carry out research at Algonquin Park Research Station.

REINO ('RAY') S. FREEMAN

(At ORF 1952–1966, and from 1967–1984 at the Department of Parasitology, School of Hygiene, University of Toronto). 'Ray' Freeman (Fig. 21) was an American scientist whose post-graduate studies were carried out at the University of Minnesota on the biology of tapeworms in porcupines. Following the award of his PhD he was appointed Assistant Professor at the Southern Illinois University, but with a heavy teaching schedule which left little time for research, he was looking for opportunities elsewhere. In 1951 at a meeting of the American Society of Parasitologists in Chicago, he was approached by Dr Murray Fallis, then Director of Parasitology at ORF, who was seeking a replacement for J.F.A. Sprent (Fallis, 1993a). Accepting Fallis' offer, Freeman arrived in Toronto in June 1952 and began his career in wildlife parasitology at Algonquin Park, continuing his earlier work on helminths. These studies included the life histories of *Taenia mustelae* and *Taenia martis* of mustelids; species of *Cladotaenia* in hawks and *Parauterina* in owls, and of *Taenia crassiceps* in foxes. His *T. crassiceps* research facilitated ophthalmologist O'Shea's diagnosis and removal of a human ocular infection by a juvenile of *T. crassiceps*, the patient's pet dog being the source of infection (O'Shea *et al.*, 1973a,b)[9]. Freeman and his graduate students also directed their attention to research on proteocephalid and pseudophyllidean tapeworms of fish. When ORF's Parasitology Department was transferred to the School of Hygiene, Freeman was one of the three ORF parasitologists who accepted transfer there (Fallis, 1993a).

Freeman's interest in parasites of fish made him most suitable to supervise the doctoral studies of Lester R.G. Cannon in the Department of Zoology at the University of Toronto between 1966 and 1970. Cannon's research on the taxonomy and life cycles of digenetic flukes in the fish *Perca flavescens* was initially carried out at Lake Sasajewun Research Station, but subsequently — and mainly — at the Lake Opeongo Fisheries Research Station, both in Algonquin Park (Cannon, 1970).

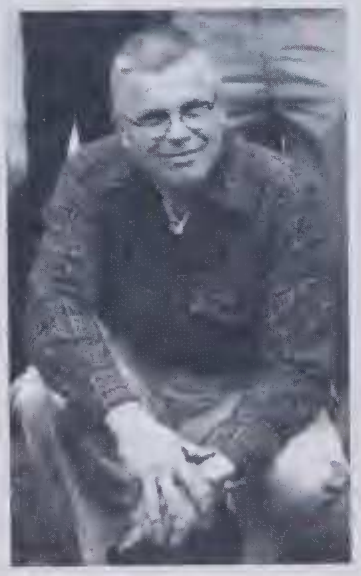

FIG. 21 Prof Reino "Ray" S. Freeman.

LESTER R.G. CANNON

(Initially at ORF from September 1966, but enrolled in the Department of Zoology University of Toronto, Sept. 1966–July 1970). Lester Cannon (Fig. 22) gained his Bachelor of Science degree at the University of Queensland with Honours in Zoology, his research project being on coccidiosis in lizards (Cannon, 1967a, b). During his Honours year in 1964 Cannon was a tutor in the Department of Zoology and also enrolled in that department, but due to the nature of his research project on parasites he was supervised by Dr H.M.D. Hoyte, protozoologist in the Department of Parasitology. Cannon, as an under-graduate, had become friendly with Dr J.C. Pearson and was greatly impressed by his classical approach to the biology of organisms in wildlife. In particular he became intrigued with Pearson's speciality, digenean trematodes. In 1966 when Pearson returned to Toronto on sabbatical, Cannon contacted him to enquire whether there was an opportunity for him to gain a scholarship to study for a doctoral degree at the Ontario Research Foundation. Cannon was subsequently accepted as a doctoral candidate in the Department of Zoology at the University of Toronto and granted a Health Science Award and an Ontario Graduate Scholarship in 1967. He arrived in Toronto in September 1966 at the time the Department of Parasitology of the ORF was in the process of transferring to the School of Hygiene. Cannon was to study with two of ORF's parasitologists, Drs Freeman and Fallis.

FIG. 22. Lester R.G. Cannon, ca. 1989.

In Toronto, Cannon elected to study the life cycles of two papillose trematodes of the family Allocreadiidae which are parasitic in freshwater fish. He investigated natural and experimental infections of perch (*Perca flavescens*) with the trematodes *Bunodera sacculata* and *B. luciopercae* in Algonquin Park (Fig. 23), as well as the inter-relationships of a fish population, its diet and its parasite community (Cannon, 1970; 1971; 1972; 1973a). His principal supervisor was Dr Reino Freeman, with co-supervision by Dr Murray Fallis along with an academic in the Zoology Department, Dr Jack Berger. Between 1968 and 1969 Cannon continued to receive an Ontario Graduate Scholarship from the University of Toronto and in the period 1969–1970, he received a National Research Council of Canada Bursary through the University of Toronto.

A parasitologist appointed to teach physiology in the Department of Zoology shortly after the integration of ORF's parasitologists with the School of Hygiene, was Dr David M. Mettrick who had established an international reputation for his African research on helminths. Soon after his arrival in Toronto, Mettrick initiated studies on the metabolism of tapeworms, using the rat tapeworm *Hymenolepis diminuta* as a

model (Fallis, 1993a). To carry out the research on this project, he appointed Christine Deane, an Honours graduate from the University of Leicester, England, with a background in research on planaria (Cannon, pers. comm.). A visiting academic to the Department of Zoology at that time was Dr J.B. (Joe) Jennings, an expert in turbellaria from the University of Leeds, England, who had come to Toronto to work with Mettrick on aspects of nutrition in turbellaria. Jennings' interest was sparked by Berger's finding small red turbellarians in sea urchins, which he showed to Mettrick. Chris Deane, as a Master of Science candidate working with Mettrick, was put to work extracting these little red worms from the sea urchins, ably assisted by her friend Lester Cannon. Indeed, in August 1968, Deane married Cannon.

Cannon was himself to become an expert on the turbellarians (Angus, 2006). Although Cannon never met Jennings during this period as he worked in another building, their mutual connection with the University of Toronto was of help when Cannon sought him out in England in 1983 to discuss a project of mutual interest. He was subsequently able to interest Jennings in coming to the Queensland Museum in 1983, 1986 and again in 1991 to carry out collaborative research on various aspects of turbellarians (Jennings & Cannon, 1985; Cannon & Jennings, 1986; 1987; Jennings & Cannon, 1987; Jennings, Cannon & Hick, 1992). Cannon had identified red turbellarians in echinoderms and also in the gut of the Crown-of-Thorns starfish *Acanthaster planci*, very similar to those found in sea urchins in Canada. Jennings and Cannon investigated this red pigment (haemoglobin) and its physiology but they also identified as a new species, *Monocystella epibatis*, a protozoan hyperparasite of the turbellarian from the Crown-of-Thorns starfish (Cannon & Jennings 1988).

Other staff members associated with the Department of Parasitology at the School of Hygiene following transfer of ORF's parasitologists were Sherwin Desser and Rasul Khan, both of whom did doctoral studies on avian haematozoa, supervised by Murray Fallis. Desser was a graduate of the universities of Manitoba and Toronto, with a particular interest in parasitic protozoa. He was appointed to the Department of Parasitology in the School of Hygiene to fill the gap left by Gordon Bennett when he departed for Queensland (Fallis, 1993a). Cannon had met Bennett only briefly in the latter months of 1966, but came to know Desser and Khan reasonably well since they were all graduate students at the University of Toronto at much the same time. Bennett and Khan were both subsequently to join Prof. Marshall Laird in the Department of Biology at Memorial University in St Johns, Newfoundland (see below).

MARINE PARASITOLOGY COMES TO THE UNIVERSITY OF QUEENSLAND

Lester Cannon is responsible for establishing marine parasitology in the Department of Parasitology at the University of Queensland, initiating both teaching and research. On completion of his doctoral studies at the Ontario Research Foundation, he accepted a post-doctoral award as Ford Foundation Fellow in Ecology at the University of California in Santa Barbara between July 1970 and August 1971, to study some consequences of parasitism to host populations. He returned to Australia in August 1971 as an inaugural Queen's Fellow in Marine Science, the Fellowship extending until the end of 1973. Cannon opted to go to the Department of Parasitology at the University of Queensland rather than accept the mooted appointment to the Australian Institute of Marine Science (AIMS), Townsville. During his Fellowship Cannon's research was conducted at Heron Island Research

FIG. 23. Black spruce swamp, typical of Algonquin Park, Ontario, where L.R.G. Cannon carried out his doctoral research.

Station on the Great Barrier Reef, such research including determining the nature and extent of parasitism in a tropical marine gastropod population and the parasitic cycles passing through the gastropod (Cannon, 1975; 1978a, b; 1979). This knowledge, and a knowledge of the biology of the snail, was used to ascertain the ecological impact of parasitism on the snail. During this time he collaborated with Ben Cropp in making a film about the Reef (Cropp & Cannon, 1973).

In the early 1970s grave concern was being expressed about the effects the Crown-of- Thorns starfish *Acanthaster planci,* was having on the Great Barrier Reef. Indeed, AIMS had been established largely as a result of lobbying by Prof. Cyril Burdon-Jones, Foundation Professor of Marine Science at James Cook University, Townsville, since he wanted scientific expertise focussed on the preservation of the corals of the Great Barrier Reef. End-on to his Queen's Fellowship, Cannon, with the support of Prof. John Sprent, was successful in obtaining a research grant from the Advisory Committee into Research on the Crown-of-Thorns starfish (an advisory body within the Department of Education and Science in Canberra). Cannon studied the distribution and abundance of parasites and commensals of the Crown-of-Thorns starfish in addition to that of other echinoderms (Cannon, 1973b; 1978a). This grant also served to facilitate the establishment of marine parasitology in the Department of Parasitology. Cannon set up appropriate laboratories at the Parasitology complex at the Veterinary Farm, Pinjarra Hills (Fig. 24). He designed modifications to part of a new building block to house aquaria which would accommodate the Crown-of-Thorns starfish. With the assistance of Con [Eric] Boel whom he appointed, Cannon constructed three-foot aquaria which had a system of water reticulation through stepped tanks. Transportation of *Acanthaster planci* tested his ingenuity. To ensure their survival, he wrapped the starfish in wet newspaper and placed them in plastic bags containing pure oxygen. The bags were then packed into large ice-cream boxes lined with styrofoam and transported by air (Cannon, 1973b). The starfish pumped out saponin once they were transferred, which frothed up the aquarium tanks quite badly. He maintained the

FIG. 24. Parasitology Complex at Veterinary Farm, Pinjarra Hills, Queensland. A, Laboratories, B, Insectaria, C, Cattle pens (left) and sheep house (right), D, close up of cattle pens.

Crown-of-Thorns starfish on a diet of frozen fish. These organisms are known to be prolific breeders — one female can produce up to 24 million eggs per season.

In June/July 1976, the Fishing Industry Research Trust Association (FIRTA), now the Fisheries Research and Development Corporation (FRDC), provided money to the University of Queensland on the proviso that a permanent appointment be made for continuation of training in marine parasitology. The University of Queensland Senate was reluctant to accept demands ensuant from funding grants, and although FIRTA did leave the funding grant in place, Cannon felt somewhat vulnerable with his salary being dependent on 'soft money'. When the Queensland Museum advertised for a Curator (Lower Invertebrates), Cannon successfully applied and took up his appointment on 8 November 1976.

Meanwhile, the Department of Parasitology having retained the FIRTA grant, needed to fill the position to teach marine parasitology. Once more there is an Ontario-Queensland association, for since there were no suitable candidates in Australia at that time, Cannon contacted his erstwhile supervisor in Toronto, Ray Freeman, to enquire if he knew of a suitable academic in parasitology who might consider coming to Queensland.

R.J.G. LESTER

(At the University of Toronto 1974–1976). Freeman advised that his recent post-doctoral fellow, R.J.G. (Bob) Lester (Fig. 25), who had done his doctorate on gyrodactylids at the University of British Columbia (Lester, 1972; Lester & Adams, 1974a, b), was currently a post-doctoral fellow at the University of Guelph. Lester was an ideal candidate for the University of Queensland position. Following his graduation in marine parasitology from Imperial College, London, he undertook a sea trip in the North Sea collecting gill parasites of whiting. He subsequently accepted appointment as a Fisheries Research Officer in Hong Kong (Lester, 1967; 1968; Lester & Watson, 1985), where he worked with Dr A.J. ('Sandy') Bruce, later to become Director of Heron Island Research Station (see below).

At the completion of the Hong Kong contract, Lester enrolled for post-graduate studies at the University of British Columbia (UBC) where his supervisor was Dr J.R. Adams (Lester, 1971). His Doctor of Philosophy degree was awarded in 1973 (Lester, 1973). Lester was then awarded

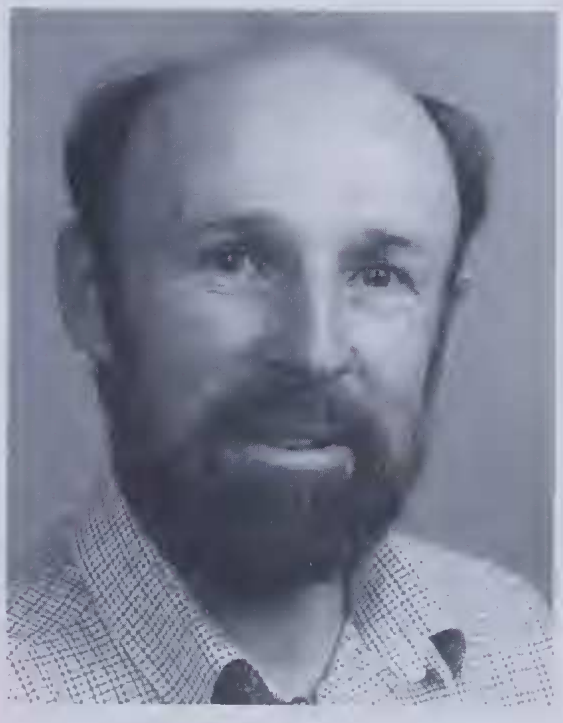

FIG. 25. Robert J.G. Lester, ca. 1997.

a 2-year Medical Research Council of Canada post-doctoral fellowship (1973–1974 inclusive), working in the Department of Parasitology, School of Hygiene, University of Toronto, Ontario. Here he worked with Dr Reino Freeman, and between 1974 and 1975 he held a Fitzgerald Fellowship. Lester and Freeman investigated the possible risk of cercariae to the eyes of bathers (Lester, 1975; Lester & Freeman, 1975; 1976). His work with cercariae led him to investigate fish responses to infection and the roles of leucocytes in fish (Lester & Desser, 1975; Desser & Lester, 1975; Lester & Daniels, 1976; Lester & Lee, 1976; Lester, 1977; Lester & Huizinga, 1977). He then moved to the Department of Pathology, Ontario Veterinary College at the University of Guelph where he investigated changes in the blood of salmon with infection, part of his research being carried out at the Pacific Biological Station at Nanaimo, British Columbia (Lester & Budd, 1979).

As a result of Cannon's contacting Freeman, both Freeman in Toronto and Adams at the UBC advised Lester of the fellowship in the Department of Parasitology at the University of Queensland (UQ). Initially declining the offer made by UQ, Lester then telephoned and accepted appointment as Teaching and Research Fellow, arriving in Brisbane in 1977. In his first year, Lester taught marine parasitology and Cannon taught the sym-

biosis part of the course. Appointed Lecturer in 1984, Lester progressed to becoming Professor of Parasitology in 1996 and in 1998 was also Head of the Department of Parasitology at the University of Queensland before the Department was integrated with the Department of Microbiology on 1st January 1999 (now the School of Molecular and Microbial Sciences). He is currently (*circa* 2007) Emeritus Professor in the Faculty of Biological and Chemical Sciences where he pursues his interests in the ecology, systematics and host-parasite interaction of parasites in wild fisheries and mariculture, as well as co-supervising honours students and giving some lectures in the 3rd level marine parasitology course.

Lester's association with Dr 'Sandy' Bruce, that had begun in Hong Kong in 1967, was re-established in 1975 when Bruce was appointed Director of the Heron Island Research Station on the Great Barrier Reef. Sandy Bruce's son Niel was at that time studying Marine Zoology at the University College of North Wales in Bangor, Wales. Graduating with First Class Honours in 1977, Niel was in 1978 awarded a Commonwealth Post-graduate Scholarship to study for his PhD in the Department of Zoology at the University of Queensland. Following completion of his PhD in 1982, Niel began work with Dr Lester Cannon at the Queensland Museum.

NIEL L. BRUCE

Niel Bruce (Fig. 26) recounts having developed an interest in tropical marine biology and taxonomy during his father's six years in Kenya as a scientist with the East African Marine Fisheries Organisation (N. Bruce, pers. comm.). During the years 1970–1974, Niel Bruce spent a considerable amount of time working on the coral reefs off the East African coast and reefs of the British Indian Ocean Territory, collecting fisheries data and fauna from the coral reef and shelf. During his Zoology Honours project on cirolanid isopods from the Red Sea, he worked at the Marine Biological Laboratories at Menai Bridge in North Wales and here began his interest in isopod and crustacean taxonomy (Bruce & Jones, 1978; Bruce, 1979; 1980b; Bruce & Jones, 1981). From these academic studies, Bruce was struck and stimulated by the realisation that so little was known of the invertebrate fauna of tropical marine environments. This prompted him to apply for admission to post-graduate studies at the University of Queensland and in 1978 he enrolled in the Department of Zoology supervised by Dr Jack Greenwood. He successfully completed his PhD in 1982 although due to unforeseen hold-ups, the award was not made until 1983. During this period he made collections of 'small crustaceans' — isopods, tanaids, amphipods, cumaceans and small decapods — on the Great Barrier Reef and at a number of reefs in the Australian Coral Sea as well as from localities around the Australian coast. Bruce's research focussed on the 'parasitic' Isopoda: Flabellifera (Bruce, 1980a, c, d, e; 1981a, b, c; 1982a, c). During his doctoral studies, he described one new family, four new genera and 14 new species.

Following completion of his doctorate in 1982, Bruce was employed by Lester Cannon at the Queensland Museum for one year on a program jointly funded by Queensland Fisheries and Commonwealth Fisheries, to identify new fishing grounds. Bruce sorted trawl catches to OTU (Operational Taxonomic Units), and identified specimens of echinoderms, poriferans, anthozoans and crustaceans to species where possible.

In 1983 he was awarded a post-doctoral fellowship to the Department of Invertebrate Zoology at the Smithsonian Institute in Washington D.C. where he completed a world revision of the fish parasitic genera *Mothocya* (see Bruce, 1986) and *Glossobius* (Cymothoidae) (Bruce & Bowman, 1989). This resolved many of the taxonomic problems of these genera, as well as fundamentally changing the understanding of host-parasite specificity in *Mothocya*. Between 1985 and 1987, Bruce was a Queen Elizabeth Postdoctoral Fellow in Marine Science at the Australian Museum in Sydney, where he worked on parasitic isopods (Cymothoidae), one of the taxonomically and nomenclaturally most difficult of the isopod families. He revised the Australian genera of externally attaching parasites (Bruce, 1987a; b; c; 1991; Bruce & Harrison-Nelson, 1988), as well as making a substantial revision of those species that attach to the gills (Bruce, 1990a).

In 1987, Cannon obtained an Australian Research Council (ARC) grant to revise the taxonomy of ascaridoid nematodes of fish in Australia and appointed Bruce to assist (Bruce, 1990a,b,c; Bruce & Cannon, 1989; 1990). Towards the end of the ARC funding, Bruce in 1989 accepted appointment as Managing Editor of the CSIRO journals, *Australian Journal of Zoology* and *Invertebrate Taxonomy*. Both journals were at that time behind schedule and, as the former editor[10] had been overstretched having been asked to deal

FIG. 26. Niel Bruce hunting wild isopods in eastern Africa: Mnemba Island, outer reef slope, northeastern Zanzibar 1997 (Photo by Matt Richmond). inset in 1996.

with 3 journals, the latter journal was attracting criticism regarding scientific reviewing and editing. By 1991, Bruce had brought the journals to their former standard. He carried on editing *Invertebrate Taxonomy* for twelve months after being awarded his own Australian Biological Resources Study (ABRS) funding grant in 1990. This project, which was to identify and describe new genera of Sphaeromatidae from Australian waters, was undertaken at the Queensland Museum.

All the while Bruce also documented parasitic isopods from other families such as the Aegidae (Bruce, 1983, 1988b, 1993, 1996), Corallanidae (Bruce, 1982a, b, c, d; Bruce, Brusca & Delaney, 1982) and Tridentellidae (Bruce,1984, 1988a).

Meanwhile, in order to complete the checklist of Ascaridoidea on fish hosts in Australia, Cannon employed, on the remainder of the ARC funding, Robert Adlard, a marine parasitologist whose doctoral studies had involved an ectoparasitic isopod, *Anilocra pomacentri*, specimens of which he sent to Bruce who formally described the species. Their combined efforts resulted in the large checklist appearing in *Invertebrate Taxonomy* in 1994 (Bruce, Adlard & Cannon, 1994).

In 1993, Bruce accepted appointment to the Zoologisk Museum at the University of Copenhagen with the rank of Associate Professor of Zoology. Here he managed the Crustacea section and was involved in developing research projects, collection development and supervising students. He also taught crustacean taxonomy during the summer field course held at Frederikshavn in the north of Denmark. The Danish climate was somewhat depressing for Bruce and his family, however, and they returned to Australia in 1997. Bruce was subsequently appointed Senior Editor to the DPI Publications at the Department of Primary Industries Queensland, before taking up a position as Senior Scientist at New Zealand's National Institute of Water and Atmospheric Research (NIWA) in Wellington. He will be returning to Queensland in October 2007 as Senior Curator, Biodiversity (Marine Invertebrates), at the Museum of Tropical Queensland, Townsville.

A SYMBIOTIC WEB: ONTARIO AND QUEENSLAND

This dissertation on the Ontario Research Foundation and the Toronto School of Parasitology, and the various associations of its members, is intended to demonstrate the importance of a 'symbiotic web' of scientists associated with ORF, and subsequently with institutions in Queensland. Beginning in 1932, the year Murray Fallis began research at ORF as a graduate student, becoming a staff member, then Head and later Director of the Department of Parasitology within ORF — and those scientists whom he appointed as staff

FIG. 27. Some of the parasitologists who attended the Workshop on Parasitology Collections held during ICOPA VI, 24–29 August 1986) (Courtesy Prof. Mary Hanson-Pritchard). A, Patricia Mawson; B, Madeline Angel (University of Adelaide); C, Harford Williams (Open University, UK); D, Ricardo Palma (University of Dunedin); E, Loutfa Khalil (Commonwealth Agricultural Bureau, St. Albans, England); F, G, Saturo Kamegai and son Shunya Kamegai (Meguro Parasitological Institute, Tokyo); H, Atsuo Ichihara (National Museum, Tokyo, and Meguro Parasitological Institute, Tokyo).

FIG. 28. Some of the parasitologists who attended the Workshop on Parasitology Collections held during ICOPA VI, 24–29 August 1986) (Courtesy Prof. Mary Hanson-Pritchard). A, Thomas H. Cribb (University of Queensland); B, Hilda Lei Ching (Canada); C, Alain Chabaud (Muséum Nationale d'Histoire Naturelle, Paris); D, Lester R.G. Cannon (Queensland Museum); E, Rod Bray (British Museum of Natural History, London); F, David Blair (James Cook University of North Queensland); G, Bjorn Berland (Norway); H, J. Ralph Lichtenfels (U.S. National Parasite Collection, Beltsville, Maryland); Mary Hanson Pritchard (University of Nebraska State Museum, Lincoln, Nebraska, USA).

and accepted as graduate students — the links forged have been important ones.

Such links date from the appointment to ORF in 1948 of Senior Research Fellow Dr J.F.A. Sprent who was subsequently to become a highly esteemed leader of parasitology in Australia — and Sprent's appointing to the University of Queensland Veterinary School, ORF graduate John C. Pearson as post-doctoral fellow in helminthology. Pearson was Sprent's initial academic staff member of what was to become the first Department of Parasitology at an Australian university. Pearson's influence on Cannon during his undergraduate years motivated Cannon to study at the institution which had imbued Pearson with a broad knowledge of natural history and a quest for excellence and integrity in research.

Arising from all the above-mentioned associations, Cannon has been able to use these many contacts to benefit research and scholarship concerning the Queensland Museum's Parasitology Collections (see below).

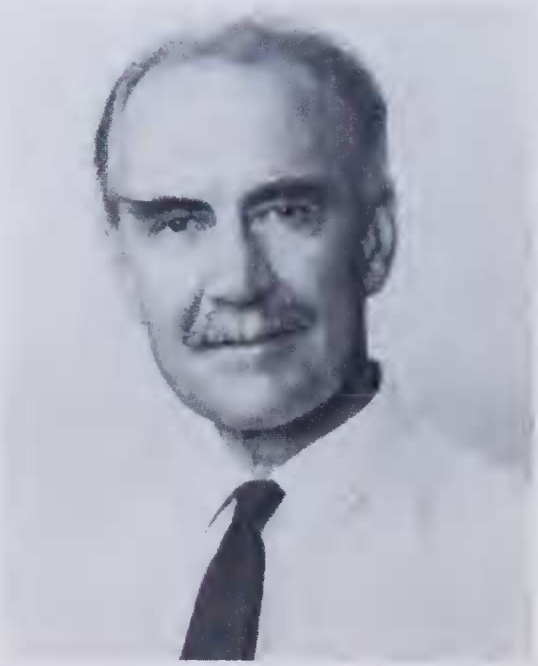

FIG. 29. Professor J.F.A. Sprent, (1915 -) Foundation Professor of Parasitology, University of Queensland. ca. 1975. (Department of Parasitology records).

THE SIXTH INTERNATIONAL CONGRESS OF PARASITOLOGY (ICOPA VI) IN BRISBANE, 25–29 AUGUST 1986

Professor John Sprent was responsible for attracting the Sixth International Congress of Parasitology (ICOPA VI) to Brisbane in August 1986. This Congress was organised through a number of committees set up by the Chairman of the Organising Committee. Lester Cannon was Satchel Organiser and Beverley Angus was Protocol Officer for the conference. ICOPA VI attracted some 1,800 delegates from 87 countries, the conference program being divided into six streams. One stream, the Parasite Assemblage, attracted the interest of Mary Hanson Pritchard, Curator of the Harold W. Manter Laboratory of Parasitology[11] in the University of Nebraska State Museum in Lincoln Nebraska; and Dr J. Ralph Lichtenfels, Curator of the U.S. National Parasite Collection held at the United States Department of Agriculture's Research Centre in Beltsville, Maryland. Prof. Pritchard's area of expertise was digenean trematodes, that of Dr Lichtenfels nematode parasites of animals. Their respective institutions in 1986 each boasted 80,000 specimen lots of parasites which placed them among the leading parasite collections held in museums worldwide. These two scientists compiled an important record of parasite collections in the world (Lichtenfels & Pritchard, 1982) in order to make available information on what parasite type specimens were held in which Museums. This question had been raised earlier by curators of parasite collections who met at the Fourth International Congress of Parasitology in Warsaw in August 1978.

At ICOPA VI in Brisbane in August 1986, Pritchard and Lichtenfels convened a special workshop to discuss the management of parasite collections and provide a forum for the general airing of views and concerns of those involved in parasite collections globally. This workshop was attended by 18 scientists representing eight countries (see Figs 27, 28). It was generally agreed that it was necessary to pursue some uniform procedures for dealing with collections and the sharing of information. In 1986, computing was becoming increasingly adopted for the storage and retrieval of information, and it was conceded by those scientists present that computerisation of records was of paramount importance — hence the need for uniformity. Records of the United States National Parasite Collection at Beltsville were being entered into 'an automated computer system' (Lichtenfels & Pritchard, 1982), but in 1986 no museum had yet fully developed a collection database.

A most significant collection in Australia at that stage was the Australian Helminth Collection (AHC) begun by T. Harvey Johnston (Fig. 7), Professor of Zoology at the University of Adelaide in the period 1922–1951. Type specimens of the AHC were at that stage housed at the South Australian Museum, the rest of the collection being held at the Zoology Department in the University of Adelaide where it was curated in an honorary capacity, by Ms Madeline Angel (trematodologist) and Mrs Pat Thomas (nematologist). These two scientists had been students of T. Harvey Johnston's at the University of Adelaide, as had been Dr Stan Edmunds (acanthocephalans). Harvey Johnston's group had gathered extensive collections both before Johnston died in 1951 and subsequently. Considerable concern was raised in the Australian Society for Parasitology (ASP) over the collections and the society had repeatedly lobbied the SAM to appoint a curator of helminthes without success. The then Director of the Queensland Museum, Dr Alan Bartholomai, had also written to the ASP offering to house and curate the collections nominally owned by the ASP, including the AHC. At the annual general meeting of the Australian Society for Parasitology held in conjunction with ICOPA VI there was considerable discussion about the AHC, with the repeated request by ASP members that the SAM appoint a curator who was a parasitologist or else consider its removal to the QM where a trained parasitologist (Cannon) was a curator. The suggestion that the AHC be moved to the Queensland Museum, however, was met with considerable resistance from Angel and Thomas who acted promptly to formalise its transfer to the SAM. It was generally unknown to members of the ASP at the time of the ICOPA VI meeting, and indeed remained largely unknown until the late 1980s, that T. Harvey Johnston had specifically willed the collection to SAM. Hence any removal from the state of South Australia was never an option (Beveridge, 1994). The South Australian Museum subsequently made it clear, however, that they would not be appointing a Curator of Helminths at that stage.

This was to have a direct bearing on the Queensland Museum's becoming the repository of important helminth collections. Arising from the SAM's apparent disinclination to appoint a parasitologist curator, Prof. J.F.A. Sprent decided to donate his extensive collection of nematode specimens, workbooks, photographs and reprints, to the QM where the parasite collection would be properly curated. The J.F.A. Sprent Collection arrived at the Queensland Museum in 1987 and served as the catalyst for other collectors to deposit their collections there. Meanwhile, Cannon discussed with Sprent the necessity of establishing a computerised national database of parasite collections, for it little mattered where specimens resided physically as long as people knew where they were. The subsequent development of such a database is discussed later.

THE GATHERING OF THREADS — THE ACQUISITION OF PARASITOLOGY COLLECTIONS AT THE QUEENSLAND MUSEUM 1986–1999

It was at the special workshop convened during ICOPA VI in 1986 to discuss the management of parasite collections worldwide, that the Queensland Museum made its presence felt internationally, despite at that stage having only modest holdings of its own. Details of global institutional parasite collections *circa* 1982 are included in the book *A Guide to Parasite Collections of the World* published by the American Society of Parasitology (Lichtenfels & Pritchard, 1982). From 1986 to date, the Queensland Museum has succeeded in attracting donations of many collections of great significance (Table 1).

In addition to attracting most of the above collections of international significance, Cannon has been responsible for establishing a robust and sophisticated database of institutional parasitology collections — the Australian Society for Parasitology Information on Collections (ASPIC) (see below).

DONATED COLLECTIONS

Between 1987 and 1999, the parasitology collections at the Queensland Museum have burgeoned to the point where they now rank among the most significant institutional collections of parasites in the world. The first of these collections to come to the Queensland Museum and donated progressively from 1987 to 1999, was that of Prof. J.F.A. Sprent, Foundation Professor of Parasitology at the University of Queensland.

THE J.F.A. SPRENT COLLECTION

Professor J.F.A. Sprent (Part B; Fig. 29) is one of the world's foremost authorities on the animal nematodes of the superfamily Ascaridoidea. Prior to coming to Queensland, Sprent's research interests had focussed on the immunology of ascaridoids and the ascarids

TABLE 1: Parasitological collections acquired by the Queensland Museum

Year of donation	Donor and nature of collection	Specimen lots
1987–1999	J.F.A. Sprent (University of Queensland): Nematoda (Ascaridoidea and others)	7,684
1987–1991	J. Walker (School of Tropical Medicine & Public Health): Partial collection (human and animal parasites)	1,581
1990–present	T.H. Cribb & students(University of Queensland): Digenea — fish	1,371
1991	M.J. Mackerras (formerly of Queensland Institute of Medical Research): Nematoda — mammals; Haematozoa — Australian vertebrates	1,503
1991–1997	R.C. Colbran (Queensland Department of Primary Industries): Plant/soil nematodes	5,114
1991	V.V. Hickman (University of Tasmania): Temnocephalans	300
1992	P.C. Young (CSIRO Fisheries Division): Monogenea — fishes	536
1994	J.C. Pearson (University of Queensland): Digenea — fish & birds	3,271
1995	G.F. Bennett (Memorial University, St. Johns, Newfoundland, Canada: WHO International Reference Centre for Avian Haematozoa (IRCAH)): Protozoa — birds	62,402
1998	K. Rohde (University of New England): Monogenea — fishes	2,200
1987 – 2000	I. Whittington & students (University of Queensland): Monogenea — fishes	>500
1987	R. Domrow: Mites	13,000
1914–1941	A.A. Girault: Chalcid wasps	2,684
2006	David Blair (James Cook University of North Queensland): Trematodes — Digenea, strigeoids and parasites of Australian wildlife	1,500
Pending	F.H.S. Roberts Collection (currently at the South Australian Museum, but promised to QM): Ticks	

of wildlife. On joining the University of Queensland Veterinary School, he concentrated initially on ascarid infections of domestic animals. One area of his research which fitted into neither of these categories but concerned a zoonotic disease in humans, was his study into a rare ascaridoid whose restricted distribution centred on the West Indies and South America (Sprent, 1971a). During a period of study leave in October and November 1968, Sprent visited Trinidad, Tobago, Surinam and Guyana. His objective was to discover the behaviour and habits of patients who had become infected with the parasite *Lagochilascaris minor*, and obtain animals for autopsy in an attempt to identify what ascaridoid nematodes were prevalent in animals in the region which might be associated with human infection (Sprent Study Leave Report, July-December 1968). As an indication of some of the stories behind the collections we present the following case-study.

Mrs Patrick's Zoonosis. Lagochilascaris minor was first described by Leiper in 1909 from specimens removed from subcutaneous abscesses of two patients in Trinidad (Leiper, 1909) by Dr Dickson, Medical Officer in Port of Spain, Trinidad (Sprent, 1971a). Leiper proposed the generic name *Lagochilascaris* because of the hare lip appearance of the mouth of the worm (Oostburg & Varma, 1968). This parasite had been reported on some ten occasions to cause purulent abscesses in the region of the ear, neck, jaw, orbit, mastoid process and retropharyngeal tissues of man (Sprent, 1971a). The most thoroughly investigated case was that of Mrs Eileen Patrick, a Negro woman born in 1923 who had lived her life in Dilaford, Tobago, except for periods in 1940, 1943, 1945 and 1957 when she visited Trinidad. At the time of Sprent's visit in 1968 she had been suffering from infection with *Lagochilascaris minor* for a period of perhaps more than 20 years. Complaining of nasal obstruction and severe neck pains in 1947, a Dr Watson in Tobago 'saw a worm' the following year according to Mrs Patrick, but no records are available. In January 1957, Dr Watson observed small worms in the pus discharged from the fistulae in Mrs Patrick's neck, which he sent to Trinidad. Mrs Patrick was subsequently admitted to the Ear, Nose and Throat Ward of the Port of Spain Hospital in Trinidad with swelling on the right side of her neck. Diagnosed as suffering from retropharyngeal abscess and nasal obstruction, she was given an antrum puncture and spent two months in Trinidad Hospital. At this time the lesion on her neck was discharging pus and it was recorded on her hospital card (16.5.57) that she had 'maggots' in the bandage on her neck. However, no identification was made of the worms sent by Dr Watson or of the 'maggots' in the bandage. Between 1957 and

1962 Mrs Patrick felt worms moving in her neck and in her nose — indeed, she expectorated worms during that period. Treatment with the anthelminthic 'Banocide' (diethylcarbamazine acid citrate) caused the worms to move to the surface 'in dozens' and exit the fistulae in her neck, the patient having by this time developed multiple sinuses (Fig. 30). In 1962 she became a patient of Dr John Draper of Tobago when she was expectorating worms and discharging worms from her nostrils. Draper made the diagnosis of infection with *Lagochilascaris minor* and reported her case history in the *British Medical Journal* (Draper, 1963). He sent both male and female worms preserved in glycerine to Prof. J.J.C. Buckley, an ascaridoid specialist at the London School of Tropical Medicine and Hygiene (Draper & Buckley, 1963). In May 1963 these specimens were relayed on to another ascaridoid specialist, Prof. Paul Beaver at Tulane University, New Orleans, together with a pus suspension containing twelve immature worms which Beaver described as 3rd and 4th stage larvae of *L. minor* (Sprent Autopsy books QM folios 150–153).

In October 1968 Prof. Sprent visited Mrs Patrick in the company of Dr Cox, the Chief Medical Officer of Tobago. She was in a nervous state and said she could still feel the worms 'crawling' in the skin of her neck. The sinus in her neck (Fig. 30) was at that time discharging pus but she did not specifically mention nasal obstruction or headache. During Sprent's interview she frequently touched her neck and wiped her hands on her face and mouth, which gave ample opportunity for re-infection if eggs exuded from the ulcer in the pus. This would explain the long period of infection. At the time of Sprent's visit, Dr Cox placed Mrs Patrick on a course of Banocide and over the three days following treatment, worms emerged by ones and twos. One immature worm and several round, unsegmented eggs and one embryonated egg emerged with pus during Sprent's second visit to Mrs Patrick in November 1968.

In endeavouring to ascertain the source of infection, Sprent questioned Mrs Patrick about her eating habits and she admitted to eating raw manacou (opossum) but could not remember what anatomical part of the animal she had eaten — e.g., head, neck, liver, lungs — or whether the opossum had been skinned (Sprent, Autopsy books QM folios 150–153). Otherwise, her diet included the usual 'bush meat' eaten by native residents of Trinidad and Tobago, which

FIG. 30. Mrs Patrick of Tobago, exhibiting cutaneous larval migrans on her neck caused by *Lagochilascaris minor*. (Courtesy Professor L.Ash, UCLA)

comprised tatou (armadillo), manacou (opossum), rats, agouti and iguana. However, it appeared that this meat was mostly eaten well-cooked and highly seasoned. Drinking water was taken from the top of rainwater tanks or nearby standpipes. The terrain in which Mrs Patrick lived was high above the sea with rich soil, dense vegetation and cocoa, coffee or banana plantations (Sprent, 1971a).

Sprent autopsied a variety of animals native to the areas where human infection with *L. minor* had been reported, but failed to find evidence of their infection with this parasite. Thus the identity of the host animal, the role it plays and the behavioural pattern which results in human infection, remained unknown.

On returning to Queensland, Sprent borrowed museum specimens of *L. minor* as reported by various authors between 1909 and 1968 and following his exhaustive examination of the morphology of the *L. minor* specimens and of the worms taken from Mrs Patrick, Sprent (1968c) considered *Lagochilascaris* to be most closely related to the genus *Ophidascaris*. He suggested that *L. minor*'s characteristic features comprise adaptations to living in tissues rather than in the alimentary tract. He further suggests that the most likely location of its predilection site in both the natural and the accidental host (Sprent, 1968c) is the upper digestive tract, particularly the crypts of the tonsils and pharyngeal region (Sprent, 1971a). The mode of human infection and the life history of *L. minor* remain to be discovered, but Sprent (1971a) considered that it would seem the parasite is erratic and abnormal in the human host, whereas it occurs normally in the alimentary tract of another animal although there is too little evidence as yet to justify any firm conclusions with regard to the affinities,

host specificity or life history of *Lagochilascaris* spp. (Sprent, 1971a). Mrs Patrick's unfortunate infection of such long duration did, however, afford some challenging research to a number of internationally acclaimed ascaridoid specialists. Details of Sprent's main research interests, and of his illustrious career, are contained in his Biographical Note in this monograph, but the above case is reported here because of its particular human interest. Arising from his study of *Lagochilascaris minor*, Sprent examined adult specimens of *Lagochilascaris* spp. from a number of sources and described a new species *Lagochilascaris buckleyi* Sprent, 1971a, based on specimens forwarded to him by Prof. J.J.C. Buckley of the London School of Tropical Medicine and Hygiene.

During a career of almost six decades he has established 10 new genera and 23 new species spanning the whole group. In acquiring the Sprent collection the Queensland Museum has obtained perhaps the world's finest collection of Ascaridoidea parasites, making it an invaluable reference centre for scholars wishing to compare material for confirmation of identifications.

The J.F.A. Sprent Collection comprises:

- 30,000 microscope slides
- 5,000 vials
- correspondence files containing letters to and from internationally acclaimed parasitologists relating to publications of Sprent's
- a valuable reprint collection
- 290 record books, including 267 autopsy books
- 14 catalogues of transparencies of both colour slides and photomicrographs
- microfilm and scanning electron microscope (SEM) pictures, including 9 photograph albums containing SEM photographs of ascaridoids listed under 37 genera.

Of particular interest is that amongst the Sprent workbooks is a record of material sent to Prof. Sprent in July 1962 by Mrs Lucy Taliaferro of the Argonne National Laboratories, operated by the University of Chicago, where her husband was Professor of Parasitology. Sprent was a Research Fellow at the University of Chicago between 1946 and 1948, working in Prof. Taliaferro's department on the immunology of *Ascaris suum* at a time when immunology was a relatively new field of science[12]. Material sent by Mrs Taliaferro for use in immunology laboratory classes in Sprent's Department of Parasitology at the University of Queensland, included a series of microscope slides and photographs which demonstrated the damage to organs and tissue caused by a variety of parasites and also by the bacterium *Staphylococcus aureus*, with the attendant cellular immunological responses[13]. These slides were accompanied by control slides of normal organs and tissue for comparison, plus notes explaining the pathophysiological and immunological effects of the respective parasitic or bacterial invasion, together with an outline of procedures for duplicating the slides for class material.

The cellular immunological response as a time sequence of events was graphically demonstrated on microscope slides by the following organisms' effects on tissue and organs:

Ascaris suum ---------- liver and lungs
Toxascaris leonina ---------- gut
Staphylococcus aureus ---------- skin
Plasmodium cynomolgi ---------- blood

There are 7,684 specimens in the Sprent Collection. To help curate and incorporate these into the Queensland Museum system, Cannon approached the Australian Society for Parasitology (ASP) for help with salary for an assistant. The ASP subsequently donated funds which the Queensland Museum matched dollar-for-dollar. This enabled Cannon to employ Mrs Marjorie Barrett, a former technician of Sprent's who had assisted him in building his collection. Marjorie was thus conversant with Sprent's records that had been scrupulously documented by Ann McKeown, Sprent's technical officer for 35 years, and who had aided in the cataloguing and curation of his collection.

THE SCHOOL OF TROPICAL MEDICINE & PUBLIC HEALTH (STMPH) COLLECTION

In June 1986 Cannon wrote to Dr John Walker (Fig. 31) at the Parasitology Section of the STMPH at the University of Sydney and Manager of the above collection. Cannon advised Walker that the Queensland Museum was soon to move to 'new, multi-million dollar premises designed to be a world-class research facility', the new premises being part of a major new development in the Cultural Centre on the South Bank of the Brisbane River, replacing the old 19th century building which had housed the Queensland Museum collections for more than 100 years. Cannon mentioned to Walker that Professors J.F.A. Sprent (Fig. 29) and J.C. Pearson (Fig. 32) had both decided to lodge their collections at the Queensland Museum. He expressed fears that,

since the STMPH was soon to be 'restructured', their parasite collection may come under threat and he offered Walker a 'sanctuary' at the Queensland Museum. Cannon furthermore stated that the Queensland Museum collections would be globally significant and he felt that the Museum's proximity to the only university Department of Parasitology in Australia made it a fitting repository for taxonomic collections. Walker responded that since most of the STMPH collection had originated in Queensland, having begun in Townsville with the early collectors Breinl, Fielding and Nicoll as well as T. Harvey Johnston, its deposition at the Queensland Museum was appropriate, particularly in view of the fact that it now included some of Josephine Mackerras' material donated by her husband, Ian Mackerras. Thus, in the latter part of 1987 the STMPH Collection of 1,581 specimens of human and animal helminths and protozoa (comprising the crucial taxonomic component) was forwarded to the Queensland Museum. Accompanying it was an extensive reprint library of more than 6,000 papers catalogued by author and subject. Some entomological and medical components of the Collection were distributed to the Department of Entomology at the University of Queensland and the Queensland Institute of Medical Research respectively, but these comprised only a small part of the total. The bulk of the STMPH collection, one third of which is nematode parasites of Australian wildlife, is now at the Queensland Museum.

The STMPH has been returned to Queensland and is now affiliated with the Queensland Institute of Medical Research and the University of Queensland Medical Faculty, both in Brisbane.

An unexpected bonus in the acquisition of the SMTPH Collection was their elegant wooden storage cabinets for microscope slides. Considering the high cost of commercially made metal storage units, Cannon enlisted the expertise of the Queensland Museum artificers to reproduce the SMTPH storage boxes to provide flat storage of microscope slides from other collections. These cost only 10 percent of the price of the commercial units, and were subsequently copied by the Department of Parasitology at the University of Queensland, and by the South Australian Museum.

R.C. COLBRAN COLLECTION

Shortly after the arrival of the J.F.A. Sprent Collection, Cannon was approached by Dr R.C. Colbran (Fig. 52), the Chief of Nematology at the Queensland Department of Primary Industries (QDPI), with regard to donating his collection of plant/soil nematodes to the Queensland Museum. This failed to eventuate, however his successor, Dr Graham Stirling, subsequently moved for the joint Australia New Zealand Agricultural Committee to nominate the Queensland Museum as the official repository for plant/soil nematodes (Cannon, Stirling & Lobley, 1993).

Cannon long believed that division of the plant/soil nematodes into two separate fields of study — plant pathology (botany), and parasitology (zoology) — is artificial. However on becoming responsible for the 5,114 QDPI specimens representing both 'worlds', Cannon quickly realised that their curation requirements were vastly different. Cannon once more successfully approached the Rural Industry Research and Development Council (RIRDC) for funds, which were matched dollar-for-dollar by the Queensland Museum. This enabled him to appoint Mrs Elaine Lobley, who had previously worked part-time in nematology with Graham Stirling. Elaine began restoration of many of the slides. She was greatly

FIG. 31. John Walker, Parasitologist at Westmead Hospital who managed the School of Tropical Medicine & Public Health (STMPH) Collection when housed at the Parasitology Section of STMPH at the University of Sydney.

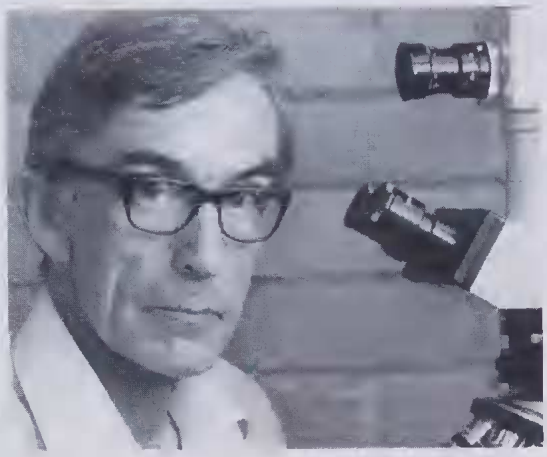

FIG. 32. John C. Pearson, Professor of Helminthology, Department of Parasitology, University of Queensland.

assisted by Frances Reay, a nematode taxonomist from the Waite Agricultural Research Institute, University of Adelaide. Reay's knowledge of the restoration and general procedures for plant/soil nematodes was invaluable. Type specimens were restored by Wim Wouts in New Zealand.

Reay brought to Cannon's attention the fact that if plant/soil nematodes are stored in alcohol (the common Queensland Museum practice for animal nematodes) they soften and are gradually destroyed. Cannon and the Queensland Museum conservator, sought the expertise of Dr Edeline Wentrub-Byrne, and her student Jan Gentner, from the Chemistry Department of the Queensland University of Technology (QUT). They identified the fact that in alcohol, lipids gradually leach out of the cuticle of plant/soil nematodes, leading to its softening. Thus plant/soil nematodes must be held in formalin, requiring vented storage to comply with Occupational Health and Safety requirements. Not only do these nematodes require specialised storage but they are in need of constant restoration. In recognition of the ongoing curatorial commitment, Dr Julie Stanton, Chief of Nematology at QDPI, pledged an annual sum of $1,000 be given to the Queensland Museum to help defray costs.

J.C. PEARSON COLLECTION

Professor J.C. Pearson (Part B; Fig. 32) is recognised internationally as one of the world's finest classical trematologists, in acknowledgment of which the University of Queensland awarded him a Personal Chair in Helminthology. Pearson's early studies concentrated on diplostome trematodes, both in his native Ontario and subsequently in Queensland. His interests switched to heterophyid trematodes when sent a few specimens collected from cats whilst writing up his doctoral thesis in Toronto, but made little progress for want of time, and better specimens were subsequently given to him by Prof. J.F.A. Sprent in Queensland. Pearson's examination of native birds and native rats showed them to be parasitised by a highly diverse and hitherto unstudied fauna of heterophyids, which stimulated him to revise groups within the family Heterophyidae (Leiper, 1909) Odhner 1914. Pearson became a world authority on this family of digenean trematodes parasitic in birds and mammals and his research on this group is considered his most important contribution to taxonomy (Cribb, 1994).

Pearson is a graduate of the University of Toronto who undertook a PhD at the Ontario Research Foundation with Prof. Murray Fallis, a distinguished parasitologist with wide-ranging interests (see above). Pearson himself is an exceptional naturalist with a love of biology in its broadest sense. His helminth collection reflects his interest in native fauna, the 3,271 specimens in his collection include not only digenean trematodes of fish, amphibians, reptiles, mammals and birds, but also 9 families of Monogenea, 14 families of cestodes and 27 families of nematodes. Specimens of digenean trematodes include representatives of over 51 families with 40 species within the family Diplostomidae and 66 within the family Heterophyidae.

In order to incorporate the J.C. Pearson collection into the Queensland Museum, Cannon again applied to the Australian Society for Parasitology who provided him with funds which the Queensland Museum again matched dollar-for-dollar. This enabled Cannon to appoint Dr Sylvie Pichelin (Fig. 33), a former student of Pearson with a PhD in helminthology, to help with the curation and incorporation of his collection. Pichelin worked at the Queensland Museum in this capacity for eighteen months, during the time Cannon was developing the ASPIC database (Australian Society for Parasitology Information on Collections) (see below). Pichelin became familiar with specimen data entry and gained valuable curation knowledge, experience that later helped her to be appointed to the new position of Curator of Helminths at the South Australian Museum in June 1994. Pichelin returned to Queensland in April 1998.

When donating his own collection to the Queensland Museum, Pearson also donated the collections of Josephine Mackerras (mainly nematodes) which he had held in trust. These were added to her existing collection of protozoa at the Queensland Museum.

THE INTERNATIONAL REFERENCE CENTRE FOR AVIAN HAEMATOZOA (IRCAH)

This outstanding collection of more than 62,000 specimens is of such magnitude and importance that it is the subject of a separate account (see below).

OTHER IMPORTANT PARASITE COLLECTIONS

P.C. YOUNG COLLECTION

A private collection of Queensland monogeneid trematodes of fishes, donated by Dr Peter Young (Fig. 34, and see biographical note in Part B), and originally collected during his PhD Fellowship at the Department of Parasitology, University of Queensland. Young graduated in Zoology in 1962, from the University of London, and thence undertook an Honours project at Imperial College, on a collection of parasites from fishes of Scotland. In 1963 he was offered a Fellowship in the Department of Parasitology at the University of Queensland by Prof. J.F.A. Sprent, who advised him that during the first year of his fellowship he would be working with a visiting professor to the department, Prof. Harold Manter from the University of Nebraska. Manter was an authority on digenean trematodes of fishes, and Young caught fish for him on Stradbroke Island and the Great Barrier Reef, which '[...]Manter tore apart and found two to three parasites per fish' (Young, pers. comm.). Young also studied with John Pearson, working on Heron Island and the Great Barrier Reef. Although initially wanting to study the ecology of monogeneid trematode parasites of fishes, Young discovered that nearly all the species he looked at were new to science, and this led to his refocussing on taxonomy (Young, pers. comm.). Howard Choat (Fig. 59), a fellow PhD candidate working on Heron Island, helped Young with identification of some of the fish. Choat went on to become Professor of Marine Biology at the James Cook University of North Queensland, Townsville.

Another important association made during Young's post-graduate studies was with Lester Cannon, at that time a tutor in the Department of Zoology. Lester was friendly with Thais Brooks, a PhD student working on coccidiosis in goats, who was destined to become Young's first wife. Cannon and Young shared an apartment in Coronation Drive, Brisbane. In 1966 on completion of his PhD, Young was appointed to the Commonwealth Bureau of Helminthology at St Albans in England, where he worked on ascaridoids in fish, marine mammals and birds. Cannon visited Thais and Peter in England[14] prior to proceeding to the University of Toronto to enroll in his own PhD program.

FIG. 33. Dr Sylvie Pichelin.

Young returned to Queensland in 1970 as a CSIRO Research Scientist with the Division of Fisheries and Oceanography, progressing to Senior Principal Research Scientist in 1986, and subsequently being promoted to Chief of the CSIRO Division of Fisheries in 1990. Between 1995 and 1997 he was President of the Australian Society of Fisheries Biology. In 1992 Cannon suggested that Young donate his small but significant collection of monogeneid trematodes of fishes (536 specimens) to the Queensland Museum, especially since most had been collected in Queensland waters.

T.H. CRIBB COLLECTION

This comprises over 1300 specimens of digenean trematodes of fishes from the Great Barrier Reef, and continues to grow. Tom Cribb (Fig. 35) was a PhD student of John Pearson at The University of

FIG. 34. Peter C. Young (1940 -), Chief of CSIRO Division of Fisheries, Hobart, Tasmania, 1990-1998. CSIRO research scientist 1970 to 1998.

Queensland. As a student he attended the ICOPA workshop, and while holding a Queen's Fellowship worked in Cannon's laboratory at the Queensland Museum. On the retirement of Prof. John Pearson he was appointed to the Department of Parasitology to teach helminthology. He is now Associate Professor in the School of Molecular and Microbial Sciences, and also the Centre for Marine Studies, at The University of Queensland.

Cribb's research interests are the biology, taxonomy and phylogeny of digenean trematodes, with particular emphases on trematodes of freshwater and marine fishes, and of native Australian mammals. His research can be categorised into several fields.

Alpha and revisionary taxonomy. Cribb has recently estimated that only 20 percent of the Australian parasite fauna is known. Thus a major priority is to work towards the eventual description of the entire fauna, determining its host and geographic distribution in Australia, and placing this information into an international context. To this end he has collaborated with colleagues in comprehensive revisions including the family Transversotrematidae (Cribb, Bray & Barker, 1992).

Life cycles. Cribb has studied the life cycles of seven trematodes within the families Gorgoderidae, Transversotrematidae and Cryptogonomidae (Cribb *et al.*, 1996). Knowledge of the life-cycles of trematodes in Australia is still fragmentary, but they are pivotal in clarifying obscure relationships between groups of trematodes.

Higher level relationships. The classification and phylogeny of the Digenea are being investigated by Cribb and coworkers through studies of digenean morphology, combined with molecular DNA techniques (shown to be useful by Barker *et al.*, 1993). This approach has been especially useful in resolving the higher taxonomic relationships of the Hemiuroidea (Bray *et al.*, 1993a, b; Cribb *et al.*, 1994).

Host-specificity and co-evolution of trematodes and their hosts. Ongoing studies focus on the trematodes of southern Great Barrier Reef fishes in collaboration with Drs Robert Adlard, Stephen Barker and Rodney Bray. Initial studies concentrated on fish of the families Acanthuridae, Chaetodontidae, Lutjanidae, Serranidae and Siganidae (Bray et al., 1993a, 1994). Molecular analyses are also being used to separate closely related species (Anderson & Cribb, 1995). Molecular markers are being used to identify the different life-cycle stages of blood flukes in freshwater fish in a study with Robert Adlard (Adlard et al., 1993).

FIG. 35. Assoc Prof. Thomas H. Cribb (1960 -) Department of Microbiology & Parasitology, University of Queensland.

PIVOTAL COLLECTIONS

Cribb and coworkers represent the sort of priority collaborations that continue to build the Queensland Museum collections in parasitology. Their collections span several phyla, ecological targets, and ecosystem functions. A prime example of the value of Cribb's collection is that it contains representatives of the small family Transversotrematidae (Fig. 36). Much research on this family has been carried out by Australian scientists, or overseas scientists working in Australia. The following recounts some of the history and people behind the research into the Transversotrematidae, and illustrates the value of the specimens within the Queensland Museum collection.

TRANSVERSOTREMATIDAE

This family was originally erected by Witenberg in 1944, who described *Transversotrema haasi* gen. nov., sp. nov. In 1969, Madeline Angel (Fig. 27B) described *Prototransversotrema steeri* gen. nov., sp. nov., a brown-pigmented trematode taken from under the scales of a mullet (*Aldrichetta forsteri*) caught in the Port River near Adelaide, South Australia (Angel, 1969). Angel was Senior Demonstrator at the University of Adelaide for many years, then an Honorary Research Fellow at the South Australian Museum in Adelaide, and at both institutions honorary curator of the Australian Helminth Collection. She suggested that transversotrematids are rarely encountered because they leave their position under fish scales soon after the fish is taken from the water. Subsequently, Harold Manter (Fig. 37), from the University of Nebraska, described *Transversotrema licinum* in 1970, while on a sabbatical with John Pearson, and Peter Young (Fig. 39) a graduate student of Sprent's, at the University of Queensland. Manter was a celebrated graduate student of Henry Baldwin Ward, the founder of the American Society for Parasitology and the *American Journal for Parasitology*, and the Harold W. Manter Laboratory of Parasitology within the University of Nebraska State Museum was founded in his honour. Until recently, his collection was curated by Prof. Mary Hanson-Pritchard (Fig. 38). Madeline Angel had visited Manter's laboratory during the mid-1960s (Sommerville, 1991) and collaborated with him on the identification of a new genus and two new species of fish digeneans (Angel & Manter, 1970).

In the early 1980s, two Queensland Government researchers, John Burke, at Walkamin Fisheries Station, North Queensland, and Lesley Rodgers of the Southern Fisheries Research Centre, Deception Bay, began investigation of a fish disease known as 'red spot'. Infected fish could not be sold because the disease's aetiology and effect on human health were unknown (Rodgers & Burke, 1988). In the hope that it might be caused by a parasite, they took an infected mullet (*Mugil cephalus*) from the Noosa River, to Dr Lester Cannon at the Queensland Museum. Cannon identified a trematode in a scale pocket as the ectoparasitic digenean, *Prototransversotrema steeri*. He also advised them that the erythematous lesions in the infected region were probably due to a bacterial infection rather than from the action of the trematode, and suggested the bacterium *Vibrio anguillarum*. Burke & Rodgers (1980) had previously isolated pure cultures of *V. anguillarum* from the fish, as well as a secondary infection by *Vibrio alginolyticus* (see Rodgers & Burke, 1988). Their subsequent research supported Cannon's view that the trematode's feeding excursions caused surrounding epidermal injury, leading to bacterial invasion by *Vibrio* spp., and consequent haemorrhaging into the tissue — hence 'red spot'. Their studies also showed that the pre- and post-spawning estuarine movement of the fish from areas of high salinity to low salinity correlated with infestation.

In the 1990s, three scientists from the Department of Parasitology at the University of Queensland, reviewed the taxonomy of the

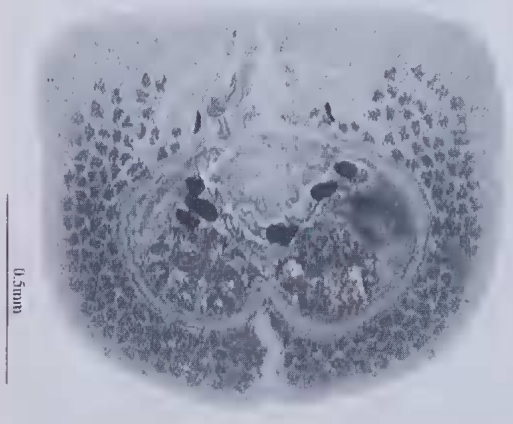

FIG. 36. *Prototransversotrema exquisitum* (Transversotrematidae) *Prototransversotrema exquisitum*, a new species within the Transversotrematidae, taken from the mullet *Liza subviridis* (Mugilidae) (Cribb, Bray & Barker, 1992)

FIG. 37. Prof Harold Manter.

FIG. 38. Mary Hanson-Pritchard.

family (Cribb *et al.*, 1992) and described a new species, *Prototransversotrema exquisitum* (Fig. 36) from the mullet *Liza subviridis* (Mugilidae), and a new genus and species, *Crusziella formosa* from *Crenimugil crenilabis* (Mugilidae). *Crusziella* was named for Prof. Hilary Crusz, a prominent trematologist (Cribb *et al.*, 1992). Type and voucher specimens from all these studies are held at the Queensland Museum.

K. ROHDE COLLECTION

Professor Klaus Rohde (Fig. 40) is a specialist in monogeneid trematodes, though his early career encompassed various aspects of zoology, physiology and parasitology. Awarded his PhD by the University of Münster in 1958, he was appointed as a research scientist by the pharmaceutical company ASTA-Werk A.G. in Brackwede, Germany, working for approximately two years at two ornithological stations. Here he developed tests for screening chemotherapeutic agents against parasitic infections (Rohde, 1959a, b, c, d, e; 1960a, b; 1961a, b).

Rohde's career as a fulltime academic began with his being appointed as Lecturer of Zoology at the University of Malaya, Kuala Lumpur in 1960, where he remained until 1967. In this capacity his brief was wide-ranging, for he conducted lectures and practical classes for first to fourth year zoology students in protozoology, lower invertebrate and crustacean zoology, parasitology, evolution, cytology and histology, animal behaviour, physiology and vertebrate nervous systems. Additionally during this 6-year period, Rohde carried out research on the ecology, taxonomy, life cycles and fine structure of a variety of helminths, but increasingly his interest became focused on the Trematoda (see Rohde, 1962a, b, c, d, e, f, g; 1963a, b, c, d, e, f, g, h, i ; 1964a, b, c). He identified one new subfamily (Rohde 1962c), two new genera (Rohde, 1962b, c), and 9 new species (1962a, b, c, f; 1963b, c, d, f; 1964c). In studies of the monogeneid trematode genus *Polystomoides*, Rohde identified one new species (Rohde, 1963b), redescribed four Malayan species, wrote a key to the known species, and compared the subcuticular layers of *Polystomoides* with some digenean trematodes (Rohde, 1965a). His ultrastructural studies (Rohde, 1965b, c, d; 1966g; 1967c, d) included investigations on the cells and tissues of the glandular and nervous systems of four species of *Polystomoides* (see Rohde, 1965f). Flukes of pathological significance were also studied (Rohde, 1965e, g; 1966c, e, f; 1967a).

Intrigued with the biology and fine structure of the sensory receptors of trematodes (Rohde, 1966g, h; 1967c, d; 1968a, c), Rohde enrolled in 1967 at the Ruhr – Universität Bocum to study for the German academic qualification, the Habilitation. For the next three years

he conducted research on the biology and ultrastructure of the aspidogastrean *Multicotyle purvisi* (Rohde, 1968b, e, f; 1970a, b, c, d, e, f, g). During this time Rohde was also a Research Fellow responsible for organising an introductory course in zoology. Awarded his Habilitation in 1970, Rohde published numerous other papers relating to this organism (Rohde, 1971a, b, c, d, e, f, g, h, 1971i, j; 1972a).

Whilst a Research Fellow in the Department of Parasitology at the University of Queensland 1970–1972, Rohde published six papers on the ultrastructure of monogeneans (Rohde, 1973a, b, c; 1974a, b; 1975a). Appointed Director of Heron Island Research Station in 1973, Rohde conducted investigations into the ecology and ultrastructure of marine parasites and corals (Rohde, 1975 b; Rohde & Sandland, 1973; Rohde, 1976a, b, c; 1977a, b, c, e). In 1975 the University of Queensland awarded Rhode a Doctor of Science degree, for his outstanding research in parasitology.

In 1976 Rohde was appointed to the Department of Zoology at the University of New England, and he extended his research interests to schistosomes of birds (Rohde 1978a), latitudinal differences in species diversity (Rohde, 1978b, c, d, g; 1979a; 1980b, c, d, e, f, g; 1981a; 1992; 1996a; 1997a; 1998b; 1999; Rohde & Heap, 1996; 1998), and various aspects of the monogenea of Australian marine fishes (Rohde, 1978e, f; 1979b, c; Rohde 1980a; 1981c; Rohde, Roubal & Hewitt, 1980; Rohde & Pearson, 1980, Combes & Rohde, 1980). He was awarded a Personal Chair at the University of New England in 1993.

His interest in the ultrastructure of parasites is evidenced by over 120 publications since 1981, seven of which were in collaboration with L.R.G. Cannon (q.v. bibliography, 1981–2000). Rohde has used ultra-structural and DNA-sequencing techniques to study the phylogeny of parasitic and free-living platyhelminthes (Ulmer & Rohde, 1981; Rohde 1981a, b, d; 1982c; 1988b; 1990c; Rohde *et al.*, 1994; Rohde *et al.*, 1995; Littlewood *et al.*, 1997, 1999; Litvaitis & Rohde, 1999; Littlewood *et al.*, 1999).

FIG. 39. Peter Young at Heron Is. helping Prof. Manter.

D. BLAIR COLLECTION

Associate Professor David Blair (Fig. 66) is a zoologist with a wide-ranging interest in various aspects of parasites, from the taxonomy of parasites of fishes and Australian wildlife to the mitochondrial genomics of flatworms. His first work was in 1972, on larval trematodes of fish and snails in freshwater habitats in Scotland and in Iceland (Blair, 1973). His PhD project was on strigeoid trematodes (eye flukes) of fish. Metacercariae of several species of strigeoid invade the lens and retina of the eyes of fish making them easy prey for their final hosts, herons and gulls. Blair's project was undertaken in response to trout farmers' concern as to the effects these parasites had on their stock. His work identified some of the strigeoids responsible for infection, their snail hosts and the annual cycle of infection of both snails and fish (Blair, 1976; 1977).

On completion of his PhD in 1974 Blair was appointed to the staff of the Department of Zoology at James Cook University in Townsville where he realised that parasites of the wildlife of tropical Australia were largely unexplored. He developed a particular interest in digeneans of dugongs and

FIG. 40. Professor Klaus Rohde, University of New England, Armidale, NSW.

chelonians (Blair, 1979; 1980, 1981a, b; 1983; 1984; 1986; 1987; Blair & Hudson 1992; Blair & Limpus 1982; Blair & Rose, 1986; Glazebrook *et al.* 1980; Lester *et al.* 1980; Platt & Blair 1996a, b). Additionally he described some taxonomically isolated digeneans of crocodiles (Blair, 1985; Blair, *et al.*, 1988; 1989; Brooks & Blair, 1978). One of the most interesting digeneans discovered was a tiny blood fluke, named by Platt *et al.* (1991), as *Griphobilharzia amoena* gen. nov., sp. nov., from the freshwater crocodile *Crocodylus johnstoni*. Males of this species of digenean completely enclose the female within what appears to be a sealed cavity communicating with the outside only through a tiny pore. Studies of this parasite might lead to a better understanding of the origins of dioecy in blood-inhabiting digenea. Incidental findings of parasites of fish in Queensland and in Papua New Guinea led to descriptions of some new species of pseudophyllid and caryophyllid cestodes (Blair, 1978; Mackiewicz & Blair, 1978; 1980). Additionally, a new genus of paramphistome was described from a wallaby (Blair *et al.*, 1979).

Blair also investigated the extent of "swimmers' itch" in North Queensland — the condition caused by cercariae of bird schistosomes penetrating the skin of bathers in mostly freshwater habitats. He identified some of the snail and bird hosts responsible (Blair & Copeman, 1977; Blair & Ottesen, 1979; Hurley *et al.* 1994) and described a new species of *Trichobilharzia* from the nasal blood vessels of ducks (Blair & Islam, 1983).

Appointed to a lectureship in the Department of Zoology at the University of Canterbury, Christchurch New Zealand in 1981, Blair developed a strong teaching program in Parasitology, as well as exploring the fauna of a region vastly different from tropical Queensland. Such investigations yielded a diverse range of treasures (Blair, 1984 a, b; Allison & Blair, 1987; Blair & Williams 1987). Marine mammals were also an interest (Cipriano *et al.* 1985; Hutton *et al.*, 1987) despite limited opportunities to work on them.

During a 12-month sabbatical at Imperial College in London, Blair worked with Dr Don P. McManus and began learning molecular skills, which heralded a move from classical taxonomy to molecular systematics of parasitic flatworms. His first publication in this field was a molecular comparison of species of fasciolid liver flukes (Blair & McManus, 1989).

Rejoining the staff of the Zoology Department at James Cook University in 1989 as a lecturer, Blair was promoted to Associate Professor in 1997. Here his research focus moved from alpha taxonomy to the systematics and evolution of parasites. Investigating the phylogeny, systematics, biogeography and evolution of morphological characters of schistosomes and other groups, he continued to collaborate with Don McManus who had joined the Queensland Institute of Medical Research in 1989, on the same day as Blair returned to the James Cook University. Growing from this collaboration was work on the molecular systematics of hydatid organisms (genus *Echinococcus*) (Bowles *et al.* 1992, 1994, 1995(a); Pearson *et al.* 2002; McManus *et al.* 2002) and of schistosomes (Blair *et al.*, 1997, 1990; Barker & Blair, 1996; Bowles *et al.*, 1995b; Le *et al.*, 2000; van Herwerden *et al.*, 1998).

Blair's research on molecular systematics led to an invitation in 1995, to be part of a consortium applying for funds for establishment of a Tropical Medicine Research Centre to be based in Shanghai, China. This was successful, and funded for six years by the U.S.A. National Institutes of Health. Blair's component of the work was to establish a sound taxonomic basis for the lung flukes (*Paragonimus*) of which some 25 nominal species were reported as occurring in China alone. From this work, and collaborations with colleagues in Japan and Vietnam, a number of papers have been published on the evolution, phylogeny and classification of lunglukes (Blair *et al.*, 1997a, b; 1998; 1999a, b; 2000; 2005; Chang *et al.*, 2000; Chen *et al.*, 2001; 2004; Cui *et al.*, 2003a, b; Hotez *et al.*, 1997; Iwagami *et al.*, 2000; Le *et al.*, 2006; Schuster *et al.*, 2006; Yang *et al.*, 2000).

An Australian Research Council grant awarded to Blair in 2002 enabled him to pursue a long-time interest with the flatworm taxon Temnocephalida. Collaborating with Dr Lester Cannon, of the Queensland Museum and his Technical Officer Dr Kim Sewell, they conducted a thorough taxonomic and molecular overhaul of the group. Of particular interest were the species associated with the spiny mountain crayfish of eastern Australia, of which many were new (Sewell *et al.*, 2006).

Blair's success at attracting research funding has allowed him the scope to explore some big-picture questions, such as the coevolution of molluscs and trematodes (Blair *et al.*, 2001), and to investigate the evolution of flatworms through molecular studies (Blair, 1993; 1996; Blair *et al.*,

1996; Le *et al.*, 2000; 2002; McManus *et al.*, 2000; 2004).

I.D. WHITTINGTON COLLECTION

Associate Professor Ian Whittington is a specialist in monogeneans of marine fishes. A graduate of the University of East Anglia in Norwich, Norfolk England, he became a post-doctoral fellow in the Department of Parasitology at the University of Queensland in January 1987, just three months after being awarded his PhD. Whittington's project was to study Monogenea of Queensland fishes (Whittington, 1987a, b, c; Whittington & Kearn, 1988; 1989; 1990a, b). A month after his arrival in Queensland, in February 1987, Whittington successfully applied for his first research grant to carry out collaborative work with Dr R.J.G. Lester on a 2-year project studying the eggs and larvae of monogeneans from elasmobranches in and around Moreton Bay and Heron Island (Whittington, 1990a, b; Whittington *et al.*, 1989; Whittington & Barton, 1990; Whittington & Kearn, 1990b; Roubal & Whittington, 1990).

In February 1988 Whittington successfully applied for an Australian Research Council (ARC) grant to carry out research with Dr J.C. Pearson on a polystomatid monogenean from the Australian lungfish *Neoceratodus forsteri* (Pichelin *et al*, 1991; Whittington & Pichelin, 1991). He was subsequently awarded a Queen Elizabeth II Fellowship in 1989 for the period 1990–1992, to study the Biology of the Monogenea. This project embraced the polystomatids from lungfish and monogeneans from marine teleosts and elasmobranches (Whittington, 1996; 1997; 1998; Whittington & Kearn, 1992a, b; Kearn & Whittington, 1992a, b; 1994; Whittington *et al.*, 1994; Whittington & Last, 1994).

In January 1993, Whittington was appointed Lecturer in Parasitology at the Department of Parasitology, University of Queensland, for a 5-year fixed term. During this time he continued to win ARC grants to support work on monogenean attachments with Dr Graham Kearn and others (e.g. Whittington *et al.*, 1994; Ernst *et al.*, 2000); on adhesives with Dr Bronwen Cribb (e.g. Whittington & Cribb, 1998; 2001), and importantly for the collections, on the taxonomy and biology of capsalids, gyrodactylids and monocotylids (e.g Ernst *et al.*, 2001; Chisholm & Whittington, 2001).

Whittington's expressed interest is to use monogenean parasites of fishes as models to examine events at the parasite-host interface, thus enabling the development of concepts about host- and site-specificity, and parasite ecology. He hopes that through using the direct life cycle of the Monogenea as a model, he can arrive at conclusions as to how parasite larvae recognise definitive hosts; why parasites choose specific sites on or in their hosts; and what cues they exploit to arrive at their predilection site, since monogeneans can inhabit a diversity of sites other than skin and gills. Models used by Whittington and his research group to explore monogenean biology, ecology and evolution have focused on teleost and elasmobranch fishes of the Great Barrier Reef, working from Heron Island Research Station. Of particular interest to Whittington are capsalid monogeneans from teleosts and elasmobranchs — a group of parasites that can be pathogenic to fishes in aquaculture and monocotylid monogeneans that parasitise sharks, rays and chimaeras. Monogeneans can be pathogenic to confined fish, especially in aquaculture (Deveney *et al.*, 2001). Studies to understand monogenean epidemiology will help fish farmers improve husbandry and management of sea cages.

Glues secreted by monogeneans as an attachment mechanism have been studied in depth in order to discover how these glues instantly stick to and detach from, wet slimy surfaces (Whittington *et al.*, 2000; Whittington & Cribb, 1999, 2001; Cribb *et al.*, 2001). This 'tissue adhesion' has implications for parasitism because it may impact on host- and site-specificity.

Dr Ian Whittington now holds a joint appointment between the University of Adelaide and the South Australian Museum.

R. DOMROW COLLECTION

Dr Robert Domrow (Fig. 41) is a world authority on sarcoptiform and trombidiform mites parasitic on Australian and Malaysian vertebrates. Beginning as a cadet scientist in 1949, he progressed to the position of Senior Entomologist (Acarology) at the Queensland Institute of Medical Research (QIMR) where he was employed until 1986.

QIMR encouraged Domrow to study entomology in the third year of his zoology degree, and during the long university vacation at the end of 1953, the Deputy Director, Dr E.H. Derrick, further arranged for him to study with Mr Herbert Womersley[15], an entomologist and a parasitic mite specialist at the South Australian Museum. Derrick specifically asked Wormersley to train

Domrow to enable him to undertake the proposed research program at QIMR during 1954:

i) To conduct a survey of acarine parasites of rodents and marsupials, extending much work already done;

ii) To breed trombiculid and allied mites' larvae so as to connect larval, nymphal and perhaps adult stages;

Overlapping i) and ii), to collect information on life history and geographical distribution of certain Trombiculid and Leeuwenhoekiid mites.

Derrick added that '[...]parasitic mites are of the most interest [to QIMR] but Domrow needs to have knowledge of the whole Order [Acarina]'.

This training was deemed appropriate in view of QIMR's research bias towards vector-borne disease. Although initially given a broad mandate to undertake research into any areas of medical science when the QIMR was established in 1945, the areas of interest at that time were zoonoses, entomology, acarology, bacteriology and mycology. Parasitology research continued alongside arbovirus research.

FIG. 41. Dr Robert Domrow, ca. 1976. (Courtesy Queensland Institute of Medical Research).

Following his training with Womersley, Domrow's first ten papers were published between 1955 and 1956 (Domrow, 1955a, b, c, d, e; Domrow & Smith, 1956; Domrow 1956a, b, c, d).

Between 22 June and 31 July 1959, Domrow was invited to attend a 6-week course in acarology at the University of Maryland and was awarded a grant of $US800 by the United States National Institute of Health (NIH) to cover his fees and agistment in the United States. Subsequently, in February 1960 Dr J Ralph Audy, Director of the University of California Medical Research Centre in San Francisco, approached QIMR requesting Domrow's secondment to establish a taxonomic unit at the Institute of Medical Research (IMR) in Kuala Lumpur, Malaya. This scheme was sponsored by the George Williams Hooper Foundation, and supported by the NIH under a United States Public Health Research Grant: National Institute of Allergy and Infectious Diseases. Domrow was seconded for six months a year over 5 years, to work in Kuala Lumpur on potential acarine vectors of the Australasian, Malaysian and Oriental regions as well as those in the Pacific area in general. The mite faunas of Malaysia and Australasia are closely related and Domrow had already been involved in work on Malaysian mites (Domrow, 1960a, c, d, e, f; Domrow & Baker, 1960; Domrow & Nadchatram, 1960).

The NIH/IMR scheme in Kuala Lumpur began in January 1961 and under a collaborative agreement between QIMR and NIH, Domrow spent two periods of study at the IMR: between January and May 1961 and again from December 1961 to March 1962. Prior to going to Kuala Lumpur he had been promoted in January 1961 to Research Officer Division I. The acarine taxonomy project involved classification of tick and mite taxonomy with a view to publication of the bionomics of Oriental-Australasian acarine vectors, covering both mites and ticks. Domrow's unit conducted fieldwork and collecting trips at Kedah Peak and at King George V National Park (Taman Negara Pahang). Their field collections were made in forest, mountain and insular habitats. Distributional and systematic studies of some peculiarly Oriental cheyletid parasites of mammals were reported in collaborative journal articles published between 1962 and 1963 (Domrow, 1962a, b, c, d, e; 1963; Domrow & Nadchatram, 1962; 1963; Domrow & Taufflieb, 1963). These included the first Southeast Asian records of Haemogamasidae, and a considerable number of descriptions of new Oriental laelapid and

trombiculid mites. Domrow's nine months in Kuala Lumpur provided an excellent introduction to zoogeography and his group discovered that some Oriental mites and their hosts differed markedly from their Australasian counterparts, although others were common to both areas.

Between 1955 and 1964 Domrow published 55 papers totalling 700 pages, which presented a complete statement of the knowledge of the parasitic mites of Australia up to that time as well as a description of 6 new genera, 3 new sub-genera and 140 new species. In the family Laelapidae he examined 20 genera from mammals and described 30 new species (Domrow, 1958a; 1959; 1961; 1962d; 1963; 1964a, d, e). This family comprises genera and species which are ecto- and mites of vertebrates and which, as blood-suckers, constitute potential or actual vectors of medical importance. In the genus *Ornithonyssus* whose species are parasites of birds, the vector mites *Ornithonyssus sylviarum* and *O. bacoti* were recorded on native birds whilst *O. bacoti* was also found to be very common on semi-domestic birds. Of the blood-sucking nasal mites prevalent in birds, only one species had been previously recorded from Australia, but on studying a total of 45 species from 8 genera he described many new species (Domrow, 1964a, b; 1965b) and created new records of zoogeographical importance.

Domrow conducted extensive studies of the family Trombiculidae which includes *Leptotrombidium deliense*, the vector of scrub typhus, *Rickettsia tsutsugamushi*. He and others (Barrow *et al.*, 1963) conducted a survey of *L. deliense* in areas endemic for scrub typhus which extended from Mossman to the Mackay-Sarina area, the southern-most limit of its endemicity. Examining 700 mammals from rain-forest and dense adjacent secondary growth habitats, *L. deliense* was found at most localities. According to Domrow, although the family Trombiculidae has been extensively studied its classification is still essentially based on the parasitic larval stages or 'chiggers'. He considers this to be an artificial classification, based on his pioneer attention to the post-larval stages which are free-living predators differing markedly from the larvae in habit and morphological structure. Domrow prepared exhaustive descriptions of twenty species of post-larvae (Domrow, 1955c, d; 1956c; 1960c, d; Audy & Domrow, 1957) which, whilst specifically inseparable, were most useful in clarifying several problematical groups at generic levels. His approach identified six new species all belonging to the one genus, *Guntherana* (Domrow, 1960b; 1964c) as well as 14 other new larval species from several genera (Domrow & Nadchatram, 1962; Domrow, 1962c, d).

Domrow identified 20 new species in studies of the families Listrophoridae and Myobiidae (Domrow, 1956a; 1958b; 1960a; 1961) which are fur mites of marsupials and rodents; and within the families Speleognathidae (Domrow, 1965a) and Epidermoptidae (Domrow, 1969), which are intra-nasal mites of vertebrates, especially birds. He confirmed the presence in Australia of discozerconids (Domrow, 1956d), ichthyostomatogastrids (Womersley & Domrow, 1959) and holothyrids (Domrow, 1955b), as well as confirming the uniqueness of the Australian holothyrids. He further recorded from Australia for the first time, 4 families and 16 new species from a large collection of free-living Mesostigmata donated by the Great Barrier Reef Committee (Domrow, 1957a).

He was promoted to Research Entomologist on 1st January 1965. Between 1979 and 1987, Domrow attracted research funding grants in order to consolidate a large but scattered mass of information on the more than 600 species of mites and ticks parasitic on Australian vertebrates. These included: 1) 1979–1984, Australian Research Grants Scheme (ARGS) leading to his compilation of an annotated checklist of the 'chiggers', or larval trombiculids (Domrow & Lester, 1985); 2) 1982–1985, Australian Biological Resources Survey (ABRS), with auxilliary funding from ARGS in 1984, leading to his compilation of an annotated checklist of the dermanyssid mites parasitic on Australian vertebrates (Domrow, 1988); 3) 1979 and 1984; and 1985–1988, part-time funding by ARGS, leading to a taxonomic revision of the 108 lower trombidiform mite species parasitic on Australian vertebrates (Domrow, 1991); 4) 1987–1990, part-time funding by ABRS, giving rise to an annotated checklist of sarcoptiform mites parasitic on Australian vertebrates (Domrow, 1992). For his outstanding and painstaking taxonomic research, Domrow was awarded a Doctor of Science, by the University of Queensland.

A DATABASE FOR THE AUSTRALIAN PARASITOLOGY COLLECTIONS

As mentioned earlier, it was following the Workshop on Parasitology Collections, held during ICOPA VI in 1986, that Cannon discussed with Prof. J.F.A. Sprent the necessity of establishing

an Australia-wide database of parasite collections in order to identify the repositories of various Australian parasite specimens. Arising from these discussions, Prof. Sprent initially contacted Dr Ian Beveridge. In a letter to him dated 11 April 1990 (QM file LIU 2/1), Sprent referred to the Australian Society for Parasitology Council's many discussions about parasite collections over the years, and the housing of the 'National' collection. Specifically, Sprent proposed that the 'Australian National Collection' comprised all the specimens in all the universities, museums and institutions in Australia; that the specimens be left where they were at present; that the Australian Society for Parasitology commence the compilation of a database of Australian parasite collections, and that software for the database be chosen which would be compatible not only throughout Australia and also with other national collections. He also listed what fields should be incorporated in the database, and recommended that the Australian Society for Parasitology should provide funding towards its establishment.

At a meeting of the Australian Society for Parasitology (ASP) Council on 5 May 1990, Sprent put forward a formal proposal along the lines outlined in his letter to Beveridge (see above). He recommended that the Society support the establishment of an Australian Parasitological Collection (APC) database to comprise details of all preserved specimens of parasites housed in institutions throughout Australia (ASP Council Meeting Minutes, May 1990). Sprent's long-term view was that the APC database could be incorporated with other international collections in order to ultimately produce a worldwide parasitology collection database. He sensitively suggested that a '[...]senior coordinator resident in neither Adelaide nor Brisbane[...]keep an expert eye on things' and suggested Ian Beveridge might accept such a commission.

General approval for this proposal was given by the ASP Council at a meeting on 9 May 1990 and Drs Ian Beveridge and David Spratt were charged with forming a committee to investigate costings of the project. Discussions took place following this meeting, between Beveridge, Spratt, Cannon, and Dr John Walker, curator of the parasitology collection then at the School of Tropical Medicine & Public Health in Sydney. In a letter to Beveridge, Cannon wryly suggested a name for the database — ASPIC (Australian Society for Parasitology Information on Collections): thus enquiries would be about 'worms in ASPIC'. Spratt had previously prepared a list of types in collections held in various Australian institutions (Spratt, 1983), along with a rough guide as to their size and content. It was unknown, however, to what extent the various helminth collections were catalogued, which made cost estimates for ASP difficult in terms of budgeting.

The *modus operandi* mooted for development of the parasitology database was to proceed in a step-wise fashion, by first sending a letter to each of the institutions which housed parasite collections, explaining the project and inviting their cooperation, and secondly to request a senior ASP member in each capital city to visit institutions and photocopy their existing records. Once information was available as to sizes and types of collections held, and the type of cataloguing employed, it would be possible to make a more detailed proposal to ASP for funding. The cataloguing of helminths was considered a priority at that stage, for several Australian museums did not register arthropods or protozoa.

On 28 May 1990, ASP donated $3,000 towards the project (QM File LI/U2) — the first payment of a total of $38,000 donated by ASP for this purpose, which the Queensland Museum matched with a dollar-for-dollar subsidy.

The Queensland Museum's commitment to a database of the Australian parasitological collection was demonstrated by their supporting Cannon's visits to major helminth collections in Europe (Cannon, 1993), during which time he liaised with curators, inspected collections and discussed curation and record-keeping at Museums in Stockholm, St Petersburg and Moscow, Berlin, Amsterdam, Ghent, London and St Albans.

At the time of his visits, only St Petersburg had a parasite database up and running, although several museums were contemplating computerisation of their collections. Cannon's tour included not only collections of helminth parasites of animals, but also of major collections of plant-parasitic and free-living nematodes.

At the same time as the ASP provided funding for the initiation of a database of records of Australian parasite collections, they provided the SAM with a computer and the cost of software to facilitate computerised cataloguing of their collection. In 1994 the SAM finally appointed as Curator of Helminths, Dr Sylvie Pichelin who had been working with Cannon for the previous eighteen months (see above). The SAM's records were entered onto the Microsoft

database program Access. These have recently been incorporated into the complete Australia-wide database.

To assist in acquiring collections, Cannon suggested formulating a 'self-help program' with documentation, together with a demonstration, that could be sent to potential donors, since he did not consider it appropriate to appoint a roving curator (QM File LI/U2, 25/5/90). He outlined a step-by-step approach for the gathering of data on collections, such data to be entered into the Queensland Museum system in Brisbane and onto the SAM system in Adelaide. The decision was subsequently made to have Cannon's assistant, Kim Sewell, accompany Cannon on an Australia-wide visit to institutions which boasted parasite collections and to photocopy their records. Other than the SAM, they liaised with or visited all the Museums in Australia. Cannon drew up a form letter containing details of the Queensland Museum's database and this was sent to the various institutions, asking curators to nominate what collections were held at their repositories. He also wrote to scientists whom he knew held private collections, asking if they would care to lodge them in the Queensland Museum (QM File LI/U2, 23/5/90). Altogether, between May 1990 and September 1993, the Queensland Museum had sent out 70 enquiries to ascertain where collections were held, and to gather data on registered parasitic helminths for incorporation into ASPIC. This included the incorporation of specimens and data of freeliving and plant parasitic nematodes. By September 1993, Cannon was confident that all collections of taxonomic significance had either been deposited in a museum, or were promised (Cannon, 1993).

Lester Cannon was an early adopter of computerised records at the Queensland Museum, gaining his initial insights from a 1979 booklet produced by the Interim Council of the Australian Biological Resources Study (ABRS)16. This publication described a mainframe computing system, the Australian Biotaxonomic Information System (ABIS), which stored information in a number of computerised data-banks at each of the participating institutions. Standard interchange protocols provided an exchange of data between these banks. Computer data management systems included automation of procedures for labeling, cataloguing and cross-referencing new accessions and providing automated validation of data fields such as latitude and longitude for location records. At the end of 1982, Cannon purchased an Osborne Executive computer with a CPM operating system, a 300 baud modem, and an Epson RX80 printer — all state-of-the-art equipment. Osborne Computers produced an early database, 'Personal Pearl' that Cannon used to enter the data for the huge Queensland Museum coral collection for which he also had curatorial responsibility. The database design was based on the ABRS standard as set down in their ABIS system. Subsequently, ABRS funding was acquired through the Director of the Queensland Museum, Dr Alan Bartholomai, to computerise the mammal data, and a land-line to the Queensland Government Computer Centre was installed. The main Museum database was then a new powerful relational database system, Microrim R:Base, running under the MS-DOS operating system. Cannon considered the R:Base platform would be highly suitable for building a parasitology database, especially as it was also being used by Prof. Mary Hanson Pritchard, in the Harold W. Manter Laboratory of Parasitology, at the University of Nebraska. It would thus be compatible with another major national parasite database. Cannon's intention was to establish a database which would have full details of all parasitic worms, held in Australian institutional collections, and eventually other parasite groups (QM File LI/U2, 23/5/91). Cannon also echoed Sprent's hope that one day a worldwide catalogue of parasites might be available.

THE AUSTRALIAN PARASITOLOGY COLLECTIONS DATABASE — ASPIC

At the ASP Council Meeting in August 1990 (ASP Council Minutes 8 August 1990) Cannon's suggestion was approved that the database be called ASPIC an acronym for 'Australian Society for Parasitology Information on Collections'. Cannon amusingly referred to the new database as 'Worms in Aspic' (Fig. 42A). Cannon also designed a logo for ASPIC (Fig. 42B). This logo is derived from a stylised A, S and P drawn in the style of a digital LED display (i.e. rectangular lines), with the A and S slid together and the P attached. It symbolises the host-parasite relationship in two ways — the dark blocks are the host, the open one the parasite or the immunological view of an antibody-antigen entity. In both ways it reflects the single entity which forms part of the parasitologist's view of the world (Cannon, 1995).

Cannon and his Technical Officer, Kim Sewell, designed ASPIC's database to include the name

of the parasite's host, the collection locality, date of collection, name of collector, holding museum/ institution and mode of storage (Cannon & Sewell, 1993). In 1996, with some funds from the ASP still available, Cannon asked multimedia designers, the Wharton Brothers (Jade Publications) to build a prototype 'front-end' to the database (Fig. 43). What resulted was a freely available, user-friendly, compact disk (CD) containing the ASPIC database, an explanation of ASPIC's development and a brief history of parasite collections in Australia, and graphics of all the Australian Museums and their curators. It was also designed to be the basis for the development of a World Wide Web page. Cannon hoped that the whole of ASPIC (including the SAM collections) would one day be made available on CD-ROM, or a similar platform such as the internet (Cannon, 1995).

With the end of the millennium, Cannon decided to incorporate all the existing collections into ASPIC and publish an updated CD-ROM. This was sent to all participating museums in 2001. A snapshot of Australia's parasitic helminth collections is thus available for everything added before 31st December 1999.

THE ASP REGISTER OF LIVING CULTURES. In June 1992, the President of the ASP, Dr Carol Behm, wrote to Cannon on behalf of the ASP Council to request that the Queensland Museum maintain the ASP's Register of Living Cultures (QM File LI/U2/76, 23 June 1992).

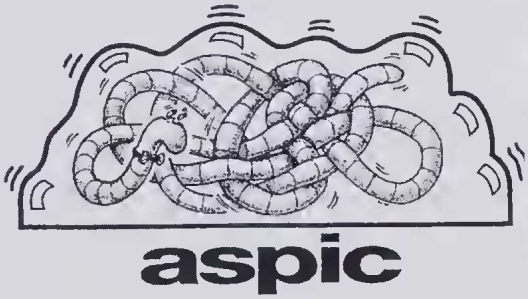

FIG. 42a. Drawing of "Worms in Aspic" which featured on the cover of a descriptive pamphlet on the ASPIC database. This pamphlet was circulated at the Annual Conference of the Australian Society for Parasitology at Heron Island in 1993.

FIG. 42b. Logo of ASPIC

Cannon agreed to keep the Register as an adjunct to ASPIC on the understanding that he assumed no responsibility for maintaining the cultures. Since that time, he has ensured that regular updates of the Register are published in the ASP Newsletter.

IRCAH'S INCORPORATION INTO ASPIC. The IRCAH (International Reference Centre for Avian Haematozoa) collection was received at the Queensland Museum in December 1995. Residual funding from the ASP's grant for the development of ASPIC, was used to employ a computer specialist proficient in designing R:Base applications. This was deemed necessary to be able to fully integrate and incorporate IRCAH data into ASPIC.

THE INTERNATIONAL REFERENCE CENTRE FOR AVIAN HAEMATOZOA (IRCAH)

The International Reference Centre for Avian Haematozoa (IRCAH) serves as a diagnostic resource for researchers and zoos around the world, containing as it does, representatives of most of the known taxa of avian haematozoa. It was originally established (as IRCAMP) in 1967 at the Department of Biology at Memorial University of Newfoundland, St John's, Newfoundland, Canada, by the United Nations World Health Organisation. It grew and flourished at its base in Canada until 1994, when it was transferred to the Queensland Museum. The QM was stategically

FIG. 43. Cover of prototype ASPIC CD-ROM.

placed to make an offer for IRCAH because it already had the only significant collections of parasitic protozoa in Australia, the result of its earlier acquisition of the major collection of haematozoa of Australian vertebrates made by Dr Josephine Mackerras' (Mackerras, 1959; 1961). Mackerras (1959) commented that the study of bird parasites '[...]can hardly be over-emphasised', and 'Many important discoveries have been made as a result of research on parasites of birds'.

The forerunner of IRCAH, IRCAMP, was established with a main purpose to undertake research on malaria in birds. It was through the study of bird parasites in India, little more than 100 years ago, that Surgeon Major Ronald Ross was able to elucidate the vector-borne nature of malaria *per se*, and the mechanism of transmission of the disease. IRCAH has since played an important role in understanding malaria, and therefore, while not directly relevant to the history of the Queensland Museum collections, we later provide (see Appendix) a brief recounting of the history of research into both avian and human malaria, which according to Foster (1965) '[...] is one of the most fascinating in the whole history of medicine'.

The IRCAH collection is especially relevant to the work of the Queensland Museum, because it had its beginnings in the blood-borne parasites of the birds of southern and eastern Asia. These can be transmitted to Australian birds by the seasonal bird migrants from the northern hemisphere. The relationships between the parasitic fauna of these migratory birds, and that of our own endemic species, provides insight into parasite transmission, host specificity and vector biology.

Originally named the International Reference Centre on Avian Malaria Parasites (IRCAMP), the basis of 'the Centre' (as it became known), was the extensive collection of Dr H. Elliott McClure (McClure *et al.*, 1978; Laird, 1998). McClure (see more later) was an ornithologist who worked for the US Army, and actively promoted bird-banding and the study of migratory birds in southeast Asia, Japan and Korea (Yoshii & Kuroda, 1999). In 1967 the United Nations World Health Organisation (WHO) designated the Department of Biology at Memorial University of Newfoundland, St John's, Newfoundland, Canada, as WHO's IRCAMP (WHO, 1967), and the Centre was inaugurated in January 1968. The late Emeritus Professor L.J. Bruce-Chwatt, CMG, OBE, played a major role in the designation of the Centre (Laird, 1998).

IRCAMP's responsibilities were detailed by Dr Bernard, Assistant Director-General of WHO, to Lord Taylor[17], President of Memorial University, as follows:

- consultation on the identification of species of avian malaria parasites;
- advice on maintaining the accuracy and possible standardisation of methods applied to the detection, geographical distribution and systematics of avian malaria parasites;
- collection of pertinent data on the catalogue of original and experimental hosts of avian malaria parasites, especially with regard to species or strains of plasmodia used for experimental chemotherapy;
- collection and maintenance of the stabilates[18] of some particularly valuable strains of species of avian malaria parasites;
- preparation and distribution of reference samples and of demonstration material, including slides for teaching purposes, if requested by the Organisation and on the basis of a special agreement;
- planning of inter-country or inter-regional surveys of the distribution, systematics and ecology of avian malaria parasites with the eventual aim of carrying out an international survey to fill in existing gaps in our present knowledge of the geographical and host-ranges of avian haematozoa.

In the years following 1968, material was added from South America, Mexico and other parts of Central America, the Republic of South Africa, Zimbabwe and Namibia. The Centre gradually changed from being a purely systematic unit, to also becoming important in other aspects of research (Bennett, 1994a). For example, a large collection of specimens from Scandinavia came from a 3–5 year study by Bennett and his colleagues at Memorial University, on the impact of blood parasites on the reproductive success and mate selection of several species of birds in relation to their resistance to infection with blood parasites (Hamilton-Zuk hypothesis). Subsequently designated the repository for avian haematozoa by the International Congress of Parasitology Associations (ICOPA) in 1975, the Centre was renamed the International Reference Centre for Avian Haematozoa (IRCAH) to more accurately reflect its evolved function and content. The Centre has also attracted material from Russia, Eastern

Europe and India (Bennett, 1994b). By 1994, 220 publications had been produced based on its collection (Bennett, 1994b). IRCAH also played an academic role with its scientists supervising 14 honours graduates, 14 Master of Science degrees, and two Doctor of Philosophy degrees (Bennett, 1994a).

THE WORK OF DR H. ELLIOTT MCCLURE (1910–1998)

Elliott McClure (Fig. 44) was a science graduate from the University of Illinois. He was awarded an MSc in 1936 for the study of insect aeroplankton (Yoshii & Kuroda, 1999). He began banding birds in 1938, and this was the beginning of his lifelong commitment to ornithology. In 1941 he was awarded a PhD by Iowa State University for his work on the ecology and management of the Mourning Dove. He joined the American Ornithological Union in 1942.

FIG. 44. Dr. H. Elliott McClure, whose collection of avian malaria parasites formed the basis of the World Health Organization's International Reference Centre for Avian Malaria Parasites (IRCAMP) which in time became the International Reference Centre for Avian Haematozoa (IRCAH). (Extracted from The Auk 116(4), p.1125).

McClure went to Tokyo, Japan in 1950 to work as an ornithologist for the 406th Medical General Laboratory of the US Army. Here he was engaged in research related to arthropod-borne zoonoses, including the flavivirus, Japanese encephalitis (formerly known as 'Japanese B'). He collaborated with Nagahisa Kuroda, who had worked with Dr O. Austin's office of Wildlife and Natural Resources, of the US Army General Headquarters in Tokyo, between 1947 and 1950; and with Masashi Yoshii (Yoshii & Kuroda, 1999). These three scientists united in their efforts to collect birds, smear their blood onto microscope slides, and forward these to a medical centre in the United States for study.

In 1958, McClure joined the US Army Medical Research Unit affiliated with the Institute of Medical Research in Kuala Lumpur, Malaya, and for the next five years studied birds in tropical jungles. Meanwhile Colonel C.M. Barnes of the Walter Reed Army Research Institute visited the Yamashina Institute of Ornithology (YIO) in Tokyo, requesting detailed information on the movement of wild birds suspected of transmitting Japanese encephalitis. Since the data of YIO were incomplete, its scientists suggested that Col. Barnes organise a project for the capture and banding of birds throughout the Far East, and recommended McClure as Project Leader (Yoshii & Kuroda, 1999). Thus in 1963, Barnes and McClure began the Migratory Animal Pathological Survey (MAPS) funded by the South East Asia Treaty Organisation (SEATO) (Yoshii & Kuroda, 1999). According to McClure *et al.* (1978) MAPS studies were supported by the US Army Research and Development Command (Far East) at Tokyo, and by the Walter Reed Army Institute of Research at Washington, DC. The MAPS project expanded over an 8-year period to include 18 Asian countries with teams operating in eleven languages — and recoveries of banded birds were reported from even further afield.

Between 1963 and 1966, McClure ran the MAPS project from Japan, moving to Thailand in 1966. MAPS operated out of Thailand until its closure in 1975 when McClure retired. During this entire period, McClure travelled to all of the countries in eastern and southern Asia promoting bird-banding co-operative activities. In its 12 years of existence the MAPS program had a working staff of 171 people, and banded 1,165,288 individual birds comprising 1,218 species. Of these, 5,602 individuals and 235 species were recovered (Austin, 1975). Considering that game laws are non-existent or lightly enforced throughout eastern

Asia, and all birds are hunted either for food, or as caged pets, these recovery rates were high (Austin, 1975). Despite the closure of the MAPS project in 1975, Asian bird-banders have increased in number, and continue to gather valuable data. These data were incorporated in a revised edition (McClure, 1998) of McClure's original Report to SEATO in 1974 (McClure, 1974).

RESEARCH AT THE ONTARIO RESEARCH FOUNDATION. The importance of arthropod vector systems in the transmission of viral as well as parasitic diseases is now well recognised. Indeed, arthropod-borne disease was one of the major lines of investigation undertaken by scientists and graduate students at the Ontario Research Foundation (ORF) in Toronto, one of whom was Gordon Fraser Bennett (Figs 18, 45A, B) who later became Curator of the IRCAH at Memorial University of Newfoundland, St John's, Newfoundland, Canada.

Research on malaria-like parasites at ORF was prompted by interest in malaria itself, since Toronto had been a prime area of infection in the 19th and early 20th centuries. Studies on avian haematozoa began soon after ORF's Wildlife Research Station opened at Lake Sasajewun in Algonquin Park in 1938 (Fallis, 1993a). The stimulus for this particular research had come from a description by C.H.D. Clarke of a parasite related to malaria, *Leucocytozoon bonasae* found in the ruffled grouse. Clarke speculated the parasite might cause mortality and be responsible for periodic fluctuations in the populations of grouse. A forestry graduate, Clarke had assisted in the survey of the Lake Sasajewun area in 1936 as a potential site for ORF's Wildlife Research Station and indeed, was responsible for its establishment (Anderson, 1986). Described by Fallis (1993a) as 'rather uninspiring', the location was chosen because of its potential for a variety of ecological studies, populated as it was by blackflies, biting midges, mosquitoes and tabanids — all of which are efficient vectors of parasitic diseases.

Many years prior to Clarke's discovery of *L. bonasae*, another malaria-like parasite of the same genus had been described by A.B. Wickware, a veterinarian in the Poultry Pathology Laboratory of the Division of Animal Pathology of the Federal Department of Agriculture. He achieved international recognition for his discovery that *Leucocytozoon simondi* caused a fatal disease in ducks. Originally thought to be a new species which he named *L. anatis* (see Wickware, 1915; Wickware & O'Roke,1934), it was subsequently found to be the same as *L. simondi,* but Wickware's discovery provided the impetus for other scientists to carry out studies on *Leucocytozoon* and related species of avian haematozoa in Canada. Moreover, it led to studies of the vectors of other blood parasites such as *Haemoproteus* and the microfilariae of various filarioid nematodes, and also of the simuliid vectors of *Leucocytozoon simondi*. In the 1940s, A.M. Fallis carried out investigations (Fallis, 1948a) into the effects of three anti-malarial drugs on *Leucocytozoon* and studies of this parasite became the major focus of his research interests. With others he defined the life history of *Leucocytozoon simondi* (see Fallis *et al.*, 1951) and also its specificity (Fallis *et al.*, 1954), its transmission and development (Fallis *et al.*, 1956).

Originally, O'Roke had thought *Leucocytozoon simondi* to be transmitted by the blackfly *Simulium venustum*, but this disease was subsequently shown by G.F. Bennett, at that time a research assistant at the station, to be transmitted by *Simulium rugglesi*. Such a finding led to the extensive study of ground-feeding as opposed to forest canopy-feeding ornithophilic flies, each group being vectors of different species of *Leucocytozoon* in both birds and mammals. Much of this research was carried out collaboratively by Fallis and Bennett (Fallis & Bennett, 1958; Bennett & Fallis, 1959; Fallis & Bennett, 1966). During a visit of the world-famous Professor P.C.C. Garnham[22] from the London School of Hygiene & Tropical Medicine in 1967, Bennett and Fallis collaborated with him (Bennett *et al.*, 1968) in reviewing the status of the genera *Leucocytozoon* and *Haemoproteus*. As his bibliography reflects, Fallis continued his research on *Leucocytozoon* species until his retirement in 1975, and is regarded as a world authority on this group of parasites. The early studies at ORF of simuliids as vectors of avian haematozoa led, years later, to related research on simuliids' role as vectors in areas outside Canada. The WHO conducted studies in Africa[23], the North Atlantic Treaty Organisation (NATO) conducted studies in Norway, and research was also carried out at the University of Canterbury, New Zealand.

Bennett's research at ORF included work on species of the blood parasites *Leucocytozoon, Haemoproteus* and *Trypanosoma*, their insect vectors and the feeding habits of these vectors, as well as their attraction to different stimuli. Additionally, he investigated louseflies (Hippoboscidae) which live on different kinds of birds, and also flies of the family Protocalliphoridae which

parasitise nestling birds. His identification of new species and a description of their life histories of protocalliphorids, led to a collaborative study with Curtis Sabrowsky, senior entomologist with the United States Department of Agriculture. Their research paper was published by the Smithsonion Institute in 1989 (Sabrowsky *et al.*, 1989).

Bennett's accomplishments in studying blood parasites and their vectors led to his being invited, in the 1960s, to join a United States Public Health Service program being conducted in cooperation with the Institute of Medical Research in Kuala Lumpur, Malaya. Here he investigated species of avian, human and simian *Plasmodium* spp. As reported earlier, in 1966 Bennett accepted an appointment with the CSIRO's Long Pocket Laboratories in Brisbane, where he worked on the cattle tick *Boophilus microplus*, the Australian vector of bovine babesiosis and anaplasmosis.

IRCAMP BECOMES IRCAH

Bennett's wealth of experience and expertise in vector-borne blood parasites led to his 1969 appointment to the Department of Biology at Memorial University, St John's, Newfoundland, following establishment of the WHO's International Reference Centre for Avian Malaria Parasites in January 1968 (WHO, 1967). Marshall Laird who had served as Chief of Environmental Biology of the WHO was appointed as Professor of the Department of Biology in 1967. Bennett and Laird set about building a reference collection of papers concerning avian blood parasites to supplement the holdings of the Department of Biology's reprint files and Memorial University's Library (Bennett & Laird, 1969).

In 1959 Laird had spent time working at the Institute of Parasitology in Montreal, and from there had been sent to northern Quebec to investigate a disease causing mortality in domestic geese. Prior consultation had taken place between officers of the Department of Northern Affairs and

FIG. 45. A, Dr Gordon Bennett shortly before his death in 1995; B, with Dr Michael Peirce, St Johns, Newfoundland (ca. 1989)

scientists at the Ontario Research Foundation as to the likelihood of a malaria-like parasite in the blood of these geese being the cause of mortality. Laird's investigations subsequently indicated that this was so (Fallis, 1993a). As Professor of the Department of Biology at Memorial University, Laird attracted large research grants and pursued investigations into the biological control of mosquitoes and blackflies. As a result of Laird's lobbying, a Research Unit of Vector Pathology was established in 1972 and some methods of biological control which were developed by the Unit led to their commercial production.

Bennett also returned to his research on avian haematozoa and blood-sucking flies and was placed in charge of the International Repository of Avian Blood Parasites which had been established with funding from WHO. In November 1969, the IRCAMP records comprised 14,300 blood films representing 760 species of 81 avian families. At that time, there were records of 24 species of avian *Plasmodium* at the Centre, with species of *Leucocytozoon, Parahaemoproteus, Haemoproteus* and *Trypanosoma* being added (Bennett & Laird, 1969). Bennett used this enormous collection of parasites from all over the world to clarify several taxonomic questions, describe new species of *Haemoproteus*, and summarise the geographical distribution of species in this genus and also in the genus *Leucocytozoon* (see Fallis, 1993a). Following establishment of the Research Unit of Vector Pathology at Memorial University, Bennett was promoted to full Professor and Head of the re-named International Reference Centre for Avian Haematozoa (IRCAH) (Fig. 45A). In order to maintain viability within the Memorial University and attract alternate funding since WHO had withdrawn financial support, it was essential to widen the scope of the Centre to include all avian blood parasites. Under Bennett's headship, the IRCAH rapidly expanded and gained international acclaim.

From 1968, a number of visiting scientists became associated with the Centre. In 1978 M.A. Peirce was appointed as a corresponding associate (Fig. 45B), and he subsequently carried out a number of collaborative studies with Gordon Bennett, resulting in many co-authored publications.

THE CONTRIBUTION OF M.A. PEIRCE

Michael Peirce's initial work with the haemosporidia began in 1961, working with *Babesia* and other tick-borne diseases of cattle whilst in the Department of Parasitology, Central Veterinary Laboratory of the Ministry of Agriculture, Fisheries and Food (MAFF) between 1961 and 1979. Peirce became interested in avian haematozoa when he identified *Haemoproteus* in blood smears of sparrows and this resulted in his first publication (Peirce, 1967). It was also the start of a long association with Prof. P.C.C. Garnham who had been the first director of the Division of Insect-borne Diseases in Kenya (Anon., 1995).

In 1968 Peirce was seconded to the East African Veterinary Research Organisation under the aegis of the Overseas Development Agency (the erstwhile 'Crown Agents' of the British Colonial Service). In Kenya, Peirce worked at

FIG. 46. Drs R.D. Adlard, S. Barker & T.H. Cribb collecting fish parasites at Heron Island, Queensland, 1991.

the Mugugu Veterinary Research Station outside Nairobi. Here his work was centred on research into tick-borne diseases and tick taxonomy, but he also carried out research on ectoparasites and endoparasites of small mammals and birds (see bibliography M.A. Peirce). It was during his two years in Kenya that Peirce met Graham Backhurst who was head of the MAPS bird-banding operation for East Africa. Peirce and Backhurst collaborated during this period (Peirce & Backhurst, 1970) and subsequently (Peirce, Backhurst & Backhurst, 1977), in studying the migration of palearctic birds. Peirce returned to MAFF at Addleston in 1970, by which time he was becoming more involved with the taxonomy of avian haematozoa and formed the opinion '[...]that the literature was in some disarray' (Peirce, 1998).

Peirce first met Gordon Bennett at a Wildlife Disease Conference in Britain in 1971 and this was the beginning of a long association as collaborator and friend. In 1973, Marshall Laird offered Peirce a position with the IRCAH in Newfoundland but Peirce declined, preferring to return to Africa. He later met Chris Mead at the British Trust for Ornithology (BTO) and this provided him with links to other ornithologists. In 1974, Peirce was invited by the British Ornithologists' Union (BOU) to join a 1-month expedition to Mauritius to survey avian haematozoa. The BOU is the principal academic bird Society in Britain. Their expedition was to carry out the 'Pink Pigeon Study' in collaboration with the Mauritius Wildlife Foundation. In the early 1970s the pink pigeon population numbered only thirty birds. As a result of an intensive conservation program the colony was bred up, but all of the pairs released to the wild subsequently died of *Leucocytozoon marchouxi*. The Mauritius collaborative study with BOU was aimed at overcoming this problem and Peirce is still associated with this project (Peirce, Greenwood & Swinnerton, 1997), the Conservation Officer in Mauritius periodically sending him blood smears for analysis (Peirce, 1998).

Following withdrawal of funding of the Centre by WHO, Bennett was able to attract funding by the Natural Sciences and Engineering Research Council of Canada (NSERCC) until 31st March 1995 (Bennett, 1994c), but with the collapse of the cod fish industry in Newfoundland, there was no likelihood of renewal of the funding grant. Bennett, therefore, sought to place the Centre with an institution which would actively curate and use it.

IRCAH MOVES TO QUEENSLAND MUSEUM

In 1993/94 Prof. Mary Beverley-Burton, Professor of Parasitology and Zoology at the University of Guelph, Ontario, Canada, visited Cannon in Brisbane. She discussed with Cannon her desire to 'find a suitable home' for the IRCAH, a problem precipitated by the fact that its champion Bennett was very ill with emphysema. Cannon contacted Rasul Khan at Memorial University to get a clearer picture of the situation (Cannon, 1994). Cannon and Khan had known each other as post-graduates at the Ontario Research Foundation and had renewed acquaintance at the Sixth International Congress of Parasitology (ICOPA VI) in Brisbane in 1986. Arising from this enquiry, Cannon received an e-mail from Bennett (Bennett, 1994a) apprising him of the fact that he was very much alive! He advised Cannon that several institutions had shown interest in acquiring the IRCAH, among them the University of Pretoria, Republic of South Africa, The University of California at Davis, and also the Manter Laboratory of Parasitology at the University of Nebraska Museum. Bennett considered the University of California at Davis 'unsafe' due to California's being located in an earthquake zone, and political instability in South Africa made that an unviable option. Bennett advised Cannon that the then Head of the Manter Parasitology Laboratory at the University of Nebraska, Prof. Mary Hanson-Pritchard, was very keen to acquire the IRCAH. However, she had retired so the 'Manter Museum' lacked a permanent curator to ensure the Centre would be maintained and used. Despite this, the University of Nebraska did make a firm offer to take the Centre (Bennett, 1994c), but Bennett's preference was that it go to a place where it would be actively used, and ideally, such a place would be a museum where it would be housed in perpetuity. Bennett applauded Cannon's initiative in developing ASPIC and added that, with the addition of the IRCAH's 'unique database' ASPIC would form part of a global database of parasites — a hope cherished by Cannon himself.

The IRCAH collection that was shipped to the Queensland Museum, is as follows:

- 145,000 records of examinations of birds;
- 35,000 positive blood smears on slides, some containing multiple infection, from birds around the world, housed in storage boxes;
- 250 hapanotypes, parahapanotypes and material identified by experts of *Plasmodium,*

Leucocytozoon and *Haemoproteus* representing virtually all the species of *Haemoproteus* known.

Additionally, their 5,650 reprints on avian blood parasites were also sent. This collection which represents 99 percent of all publications in the field and is the most complete in the world, exceeding the combined collections of Oxford, Cambridge and the Liverpool and the London Schools of Hygiene & Tropical Medicine (Bennett, 1994d).

Bennett devoted much time to building the Centre's collection, and the literature pertaining to it, and to analysing the information. His activities included identifying material for colleagues in collaborative research projects which he often designed himself, publications arising from this research forming the basis of their database. According to Bennett (1994c) some of their research was becoming the basis of the Hamilton-Zuk hypothesis and also of the Resources Provisioning Hypothesis. Such data facilitated the building up of host-parasite catalogues and studies on parasite distribution on a global basis. Memorial University of Newfoundland in 1982 and 1992 published the monumental host-parasite catalogues compiled by Bennett and colleagues, listing records up to 1992 (Bennett *et al.*, 1982; Bishop & Bennett, 1992). Bennett's aim had been to describe and determine the host and geographical distributions of the blood parasites in all the families of birds in the world. He came close, the 1982 catalogue listing the blood parasites in 3,816 bird species (40% of those known), these representing 152 of the 175 avian families (Anderson, 1996). The catalogue was continuously up-dated with new records, though since 1992 the Memorial University of Newfoundland (MUN) had acquired records of new hosts yet to be entered.

Negotiations between Cannon and Bennett regarding the Queensland Museum's acquisition of the Centre, took place from 21 March 1994 to 11 May 1994, the date when Cannon was finally able to advise Bennett that the Director of the Queensland Museum had authorised its acquisition. The Queensland Museum approved contributing $AUD5,000 towards the shipping costs, which Bennett had ascertained would be $C9,700 + $350 insurance for a total value of the collection of $C75,000. The MUN offered $C5,000 for rehousing the Centre.

The IRCAH collection arrived at the Queensland Museum in November 1995. Sadly, Bennett died on Xmas eve in 1995, so his hopes of visiting Brisbane in a consultative capacity were never fulfilled. The existing international consultative group of the IRCAH became affiliates of the Queensland Museum.

Because of its significance as the world's leading collection of blood parasites, the Queensland Museum in June 1996 appointed as Curator of Protozoa, Dr Robert D. Adlard.

ROBERT ADLARD'S CUSTODIANSHIP

Robert Adlard's background is detailed in Part B of the present work. Following his appointment as Curator of Protozoa, Adlard publicised the Queensland Museum as the current repository of the IRCAH in *Systematic Parasitology*, and extended an invitation to researchers to study or deposit new material at the Queensland Museum (Adlard, 1997). In January 1997 Adlard initiated a project with the Currumbin Wildlife Sanctuary to study avian haematozoa in their captive birds, with the aim of determining the species present, functional vectors, and their inter-relationships. Veterinarians at the sanctuary took blood smears direct onto microscope slides. Haemosporidia belonging to species of *Leucocytozoon, Plasmodium,* and *Haemoproteus* were identified.

In 1999 a German post-graduate student, Rose Lederer, joined Adlard at the Queensland Museum. Rose, a Veterinary graduate from the Ludwig Maximillian University in Munich, had previously visited a veterinary practice in Melbourne for work experience during her undergraduate studies. She revisited Australia seeking a post-graduate project on avian haematozoa, and her enquiries led to Adlard at the Queensland Museum. Adlard advised that a project on the pathogenesis of avian haemosporidia would complement his own studies on the taxonomy and biology of avian haematozoa in southeast Queensland. He assured her that the resources of the IRCAH would greatly contribute to the success of her project. Dr Peter O'Donoghue, a protozoologist at the University of Queensland's Department of Microbiology and Parasitology, agreed to act as co-supervisor.

Lederer returned to Germany and successfully applied for a funded post-graduate fellowship from Deutscher Akadimischer Austauschdienst (DAAD), to study for her Doctor of Veterinary Medicine degree in Australia. For her German supervisor, O'Donoghue was able to interest Prof. Michel Rommel, an associate of O'Donoghue's

during his years as a von Humboldt Fellow at the Max Planck Institute in Hanover, Germany.

Lederer arrived in Brisbane on 5 October 1998 and Adlard arranged for her to work with staff of the Currumbin Wildlife Sanctuary in order to collect blood samples as part of his collaborative project with the sanctuary. During a 4-month period working with the resident veterinarians, she sampled 500 birds and these blood collections generated the material for her study on the characterisation and pathology of avian haematozoa. Rose Lederer was awarded her Dr Med. Vet. Degree in December 2000 and graduated *summa cum laude*.

Following his initial appointment as Curator of Protozoa, Adlard concentrated on strengthening links with international researchers and welcoming them to the Queensland Museum to work on the IRCAH. In this capacity, he hosted Dr Michael Peirce to a three-week stay in the latter part of 1999. During this time they prepared a manuscript describing three new species of *Leucocytozoon*, two from Australian material collected by Lederer and one from material which Peirce had received from

FIG. 47. Dr M.A. Peirce (left) and Dr Robert Adlard (right) attending the Symposium on the Ecology of Bird/Parasite Interactions in Vilnius, Lithuania.

FIG. 48. Delegates at the Vilnius Symposium. Dr. G. Valkiunas (standing).

the Middle East (Adlard, Peirce & Lederer, 2000). Adlard and Peirce were successful in attracting ABRS funding to collaborate on the taxonomy and biology of avian haematozoa in Australia for 2001–2002. This was aimed at addressing the comparative paucity of information on avian haematozoa in this country.

In 1998 Adlard was invited by Dr Gedeminis Valkiunas of the Lithuanian Institute of Ecology and one of the corresponding associates of the IRCAH, to speak at a Symposium held in Vilnius, Lithuania, on the Ecology of Bird/Parasite Interactions (Adlard, 1998) (Fig. 47). There has been ongoing interaction with Dr Valkiunis (Fig. 48) since that time regarding avian haematozoa and their systematic relationships, and making available to him, specimens and data of the IRCAH collection.

In 1999 Adlard hosted a 2-month visit from Dr Elena Muñoz of the Autonomous University of Barcelona, Spain. During her visit to the Queensland Museum, Adlard was able to assist her to identify species of haemosporidia she had found in birds of prey in Spain (Muñoz *et al.*, 1999). In collaboration with O'Donoghue he compiled a comprehensive host-parasite checklist of protozoan species from Australian animals (O'Donoghue & Adlard, 2000).

Interest and activity continues in the IRCAH. Dr Rob Fleischer (Head of Genetics, Smithsonian Institution, Washington DC) and Dr Carter Atkinson (USGS, Hawaii) visited the Museum in February 2002 to obtain molecular data on bird malaria, using a portable PCR laboratory they brought with them (Fig. 49).

THE NEW MILLENIUM

A NEW BEGINNING?

With rapid acquisition of collections following ICOPA VI it was deemed valuable to visit, as far as possible, other parasite collections held in the world (Lichtenfels & Pritchard, 1982). This was to ensure curation and information procedures were optimal at the QM, and to improve communications between the curators of international parasite collections. In 1990 Cannon visited Asia, and in 1993, Europe. Then in September and October 1998, funded by the Queensland Museum's Colliver Scholarship[24] he was able to visit collections in the Americas.

FIG. 49. IRCAH visiting scholars – Dr Rob. Fleischer (Head of Genetics, Smithsonian Institution, Washington DC), Dr Adlard, Jon Beadwell (Research Assistant, Smithsonian Institution), Dr Peirce, Dr Carter Atkinson (USGS, Hawaii). Feb 2002.

Cannon estimated that there is a world collection of about 1.5 million parasite specimens, of which Australia has about 10 percent. His travels provided him with information on institutions worldwide which house more than 50 percent of the world's parasite specimens. He obtained a very broad exposure to collections of parasites and their curation. It was apparent that everywhere curators felt under threat. Globally, science policies are changing, and budgets for whole organism studies are shrinking as attention focuses on molecular biology and technology, i.e., there is a movement away from the study of morphology and taxonomy.

Accordingly, this trend forecasts that specimen-based research, as hitherto taught in Universities and where teaching and research collections have often been housed, will decline. Museums, therefore, have an increasingly important role to play in championing the maintenance and further building of collections of the natural world, in educating ongoing generations of both students and the general public, and in promoting knowledge of both morphological taxonomy, and the inherent value of collections as irreplaceable DNA resources.

The housing of collections at the institutions visited satisfied Cannon that storage facilities at the Queensland Museum were comparable with any in the world. With the advent of CD-ROM and the World-Wide-Web the opportunity to make collection data available quickly and easily is a growing global phenomenon. This places added pressure on institutions to ensure data accuracy. The rapid expansion of the collections at the QM has meant the new computer based technologies have been utilised and the generosity of The Australian Society of Parasitology to augment museum funds has seen the QM able to hold its place in the world.

A new development brought on by the computer revolution is that of digitising images and the possibility of modeling in 3-dimensions. Since type specimens provide the authoritative basis to correctly name and understand the relationships of organisms, and considering the increasing threat to proper curation and maintenance of parasite collections not only at the Queensland Museum but worldwide, digital techniques provide the opportunity to create virtual specimens from 2-dimensional images for 3-dimensional reconstructions. Such images may provide much of the data that researchers now seek, thus relieving museums of the toil of packaging and posting loans of specimens — a practice which can lead to damage and sometimes loss of valuable material, not to mention the increasing problems of transporting ethanol preserved specimens as 'dangerous goods' worldwide.

Biological collections are the basis for accurate identification of species, and thus underpin most biological study. The QM collections will continue to provide the morphological basis for identification, but will also continue to expand their competency with molecular techniques for species recognition. Phylogenetic research increasingly seeks to marry both data sets to better understand how the tree of life has evolved, and indeed to resolve specific taxonomic problems arising from over-reliance on morphometric data for 'ultra conservative' phyla that show limited morphological divergence but significant genetic distance.

PARASITOLOGY IN QUEENSLAND — *QUO VADIT*?

From strong medical, veterinary and agricultural roots, parasitology blossomed in the latter half of the 20th century, but, after almost forty years as a fully autonomous and prestigious department, the Department of Parasitology at the University of Queensland has been subsumed into the School of Molecular and Microbial Sciences. The Queensland Museum with its large and significant collections is placed to become of major importance to parasitology research in Queensland.

PART B: BIOGRAPHICAL NOTES ON COLLECTORS AND THOSE OF INFLUENCE

ROBERT DOUGLAS ADLARD (1955–)

Robert Adlard (Fig. 66) was born in the village of Shanklin on the southeast coast of the Isle of Wight, Great Britain, and came to Brisbane with his family in 1965 at the age of nine. On leaving school in 1974 he became a geological technician with the Queensland Department of Mines where he took regional surveys of the surface geology of areas in Queensland, carried out wireline log testing of stratigraphic drill holes using gamma, resistivity and spontaneous potential probes, and undertook various laboratory and office duties. In 1979 he resigned in order to undertake fulltime undergraduate studies in biological science with a major in zoology. Since he had aquatic interests, Dr Jack Greenwood was his academic adviser in the Department of Zoology, but he also did some toxicology studies with Dr Ann Cameron in the

same department. Adlard's undergraduate course included subjects in parasitology: Arthropods and Protozoa taught by Dr H.M.D. (Duncan) Hoyte, Immunology by Paul Brindley and Dr R.J.G. (Bob) Lester's very applied marine parasitology course. These subjects stimulated his interest in parasitology from the point of view of the interaction of the parasite with the host, resulting in his enrolling for an Honours year with Bob Lester following his graduating BSc in 1982. Adlard's project was to study white spot disease in marine fish, looking at the timing of the life cycle of the ciliate *Cryptocaryon irritans* with a view to its non-chemical control. He was based at the Veterinary Farm Precinct at Pinjarra Hills (Fig. 24) and used the departmental motorboat to carry out seine-netting in Moreton Bay. For successful completion of this study, Adlard was awarded 2A Honours (Adlard, 1983).

There followed a hiatus in parasitology studies for several years when he worked as a Park Ranger at Lone Pine Koala Sanctuary, which included acting as a public relations officer and education officer. At the end of 1984, his honours supervisor, Bob Lester attracted a Marine Science and Technology grant for financing a PhD project. Adlard successfully applied. He was to investigate the effects of parasites on the population dynamics of reef fish. Accordingly, he completed a SCUBA training course and in February 1985, went to Heron Island to conduct a pilot study to determine the right candidate parasite and fish for the project. The ectoparasitic isopod *Anilocra pomacentri* and the reef fish *Chromis nitida* filled these criteria and Adlard was posted to Heron Island where his wife, who also underwent training in SCUBA diving in order to be his 'dive buddy', joined him in July 1985. On one occasion he was fortunate to witness and photograph coral spawning — one of the few times it had been photographed. His pictures are included in Cannon & Goyen's (1989) book *Exploring Australia's Great Barrier Reef* (see Plates 28 and 82).

Between 1985 and 1988, Adlard presented the results of his PhD work at five conferences, and had Abstracts published in their Proceedings. He was awarded his Doctor of Philosophy on 1st March 1990 (Adlard, 1990). One of his examiners was Dr L.R.G. Cannon. Two research papers from his thesis were published (Adlard & Lester, 1994; Adlard & Lester, 1995a).

In 1988, Adlard was a contract scientist for CSIRO's Cleveland Laboratories to study the distribution and abundance of seagrass in Torres Strait. Following submission of his doctoral thesis in 1989, Adlard worked briefly as Research Assistant to Dr I.D. Whittington in the Department of Parasitology, on the biology and taxonomy of monogenean parasites of fishes from Heron Island. He was then appointed by Cannon at the Queensland Museum, to complete the compilation of a checklist of the ascaridoid nematodes of fish (Bruce, Adlard & Cannon, 1994) funded by the remains of an ARC grant. In 1990, Adlard was appointed on a short term contract as Senior Research Assistant to Dr T.H. Cribb, a Queens's Fellow working with Cannon at the Queensland Museum. Cribb needed someone to help him who had boating skills and experience at sampling fish for digenean parasites (Barker *et al.* 1994; Cribb *et al.*, 1996; Mollaret *et al.*, 1996 and Cribb *et al.* 1998). In the same year, Adlard and a fellow doctoral candidate, Mattias Voigt from Germany, set up as partners in a consultancy company called Aquabiotics to conduct environmental impact studies of proposed and in-place developments. Voigt returned to Germany at the end of 1990 and Adlard continued the business single-handedly throughout 1991, advertising by direct mail to Town Councils, Government bodies and engineering companies, as well as scanning the newspapers for tenders. Twenty-two contracts were successfully completed during this period.

In 1991, Adlard was employed part-time in the Department of Parasitology on an ARC research grant, to investigate at a molecular level, the taxonomic association of fasciolid flukes in Australia (Adlard *et al.*, 1993), and of cattle ticks in Australia and Africa. Techniques employed were extraction of DNA, amplification of rDNA using the polymerase chain reaction (PCR), manual sequencing with radioactive labels and analysis.

In 1992 Adlard was appointed to the Department of Parasitology as a post-doctoral research associate on a three-year ARC grant to study, using molecular techniques, the diabnosis and epidemiology of *Mikrocytos* and *Bonamia*, pathogens of Australian cultured oysters. He and Lester collaborated on the development of a diagnostic test for *Mikrocytos roughleyi* which causes winter mortality of the rock oyster (Adlard & Lester, 1995b). His success with this project resulted in his being employed as a Research Fellow in the Department of Parasitology between 1995 and 1996, on an FRDC grant, to investigate, diagnose and formulate control measures for *Marteilia sydneyi* causing QX disease, and *Mikrocytos*

roughleyi causing winter mortality in oysters in eastern Australia. In carrying out benthic sampling of fauna in the Georges River, he found there was a correlation between the presence of polychaete worms and QX disease. Oyster-to-oyster transmission of disease had already been investigated by Roubal & Lester (1987). Adlard theorised that polychaetes may act as alternate hosts for the QX disease organism since sporonts released from oysters were 'negatively bouyant' and sank to the bottom. Using PCR, he tested polychaetes and found them to be positive for QX disease.

Adlard's research on parasitic pathogens of oysters has gained him much kudos. In 1994 he was invited by Prof. D. Schnack, Director of Fisheries Biology at the University of Keil's Institute of Marine Science, to present a lecture on the molecular diagnosis of pathogens in marine culture. In 1994 he was presented by the then Queensland Premier, Wayne Goss, with an award from the Queensland Oyster Growers' Association, for 'Fostering outstanding advances in the genetics of oysters and their diseases' (Fig. 50). Between 1994 and 1997 he was invited to present industry seminars on oyster pathogens to both the Queensland and the New South Wales oyster growers' associations, and to the Fisheries Research Institute at Cronulla in Sydney. Additionally, he produced reports on *Bonamia* sp. in flat oysters from Tasmania (Adlard, 1993a), decreased growth in rock oysters from Port Macquarie (Adlard, 1993b); the control of winter mortality and QX disease (Lester & Adlard, 1996) and the presence of QX disease in rock oysters on the central coast of New South Wales (Adlard & Lester, 1996).

In June 1996, Adlard was appointed to the Queensland Museum as Assistant Curator, Protozoa. He was promoted to Curator of Protozoa in June 1997. In January 1997 he initiated a project with the Currumbin Wildlife Sanctuary, studying avian haematozoa in local birds. In 2004 he became a Senior Curator, his position entailing curation of protistan collections, in particular the International Reference Centre for Avian Haematozoa (IRCAH), and research on taxonomy and biology of mainly protistan parasites of birds and fishes, and aquatic diseases.

In terms of his dual responsibilities for marine and avian protozoa as a Senior Curator, Adlard has a number of ongoing collaborative research projects.

Marine Protozoa. Adlard was invited to run a workshop on oyster disease at the Fish Health Section (American Fisheries Society) conference in Pensacola, Florida, U.S.A. in September 2000. He then visited Oregon, USA, to liaise with Dr Michael Kent, Director of the Salmon Disease Research Centre at Oregon State University with respect to their mutual investigations into haemosporidia and microsporidia of fish. He is currently funded from the FRDC and the Fisheries Research Fund to continue studies on the pathology of protozoan diseases of oysters.

Adlard also undertook collaborative projects with Drs Ian Whittington and Leslie Chisholm (formerly of the Department of Microbiology and Parasitology at the University of Queensland, but now of the South Australian Museum with conjoint appointment to the University of Adelaide), on molecular characterisation and systematics of capsalid and monocotylid monogeneneans. With Dr Tom Cribb he works on determinants of the distribution of digenean parasites of coral reef fishes.

Avian Protozoa. Dr Michael Peirce, a world authority on avian haematozoa, visited the Queensland Museum in 1999 and 2002 to work with Adlard and German PhD student Rose Lederer, on avian haematozoa in southeast Queensland. Adlard acquired research funding to allow Peirce to return to the Queensland Museum on one-month visits in order to address the comparative paucity of information on avian haematozoa in Australia.

In 1998 he was invited by Dr Gediminas Valkiunas (Fig. 48) of the Lithuanian Institute of Ecology to address a Symposium on the Ecology of Bird/Parasite Interactions being held in Vilnius, Lithuania, on the current status of the IRCAH. A visitor from the University of Barcelona, Dr Elena Muñoz, gained Adlard's assistance (Muñoz *et al.*, 1999) in identifying species of haemosporidia found in birds of prey from Spain, during a 2-month visit to the Queensland Museum.

In 1998, Adlard was elected to the Council of the Australian Society for Parasitology. In 1999 he was appointed Honorary Research Consultant to the Department of Microbiology and Parasitology at the University of Queensland, where he co-supervised four PhD candidates — Kleeman, Wesche, Cameron and Jakes. Following award of his PhD, Wesche was appointed by Adlard as a Research Officer at the Queensland Museum on a FRDC grant entitled: 'Aquatic Animal Health

Subprogram: Development of a disease zoning policy for marteiliosis to support sustainable growth'.

In February 2000, Adlard and Dr Peter O'Donoghue of the Department of Microbiology and Parasitology published a catalogue of protozoan parasites recorded in Australia (O'Donoghue & Adlard, 2000). This monograph comprises both a host-parasite checklist and a parasite-host checklist, together with a cross-referenced bibliography. In 2004 Adlard was cross-appointed with the University of Queensland as a Senior Lecturer in the School of Molecular and Microbial Sciences, and since then has successfully supervised numerous PhD, MSc and Honours students.

In August 2006 Adlard was appointed to Head of Marine Zoology, within the Biodiversity Program of the Queensland Museum. Most recently he was awarded a one-year FRDC grant to determine intermediate hosts in oyster disease.

He has been immortalised with the following patronyms:

Lepostrema adlardi Bray & Cribb, 1993 — a species of digenean parasitic in coral reef fish

Acanthoplacatus adlardi Ernest, 2001 — a species of monogean parasitic on fish

Acanthobothrium adlardi Campbell & Beveridge, 2002 — a species of cestode from elasmobranchs.

FIG. 50. Dr. Robert Adlard receiving the Queensland Oyster Growers' Association Award from the then Queensland Premier, Wayne Goss in 1994.

GORDON FRASER BENNETT (1930–1995)

Gordon Fraser Bennett was the son of Scottish settlers to southern Ontario who became Baptist missionaries to India — his father as a clergyman, his mother as a physician. Gordon Bennett was born in southern India in 1930, and received his early education there before returning to Ontario for secondary school studies (Anderson, 1996). Graduating from high school in 1949, he applied for admission to the Faculty of Forestry but was turned down because of his very small stature, being only 160cm tall and weighing 57kg (Fallis, 1993a). He subsequently enrolled in Biology at Victoria College at the University of Toronto. Intending to specialise in zoology, he enrolled in the honours course in science but was persuaded by one of his professors, Prof. A.F. Coventry, to consider parasitology since he had spent much of his life in India and had a familiarity with parasites, having himself suffered from attacks of malaria as a child. Professor Coventry suggested Bennett should approach Prof. A. Murray Fallis about working as a summer undergraduate student at the Ontario Research Foundation's (ORF) Wildlife Research Station at Lake Sasajewun in Algonquin Park, where a great deal of research was carried out on parasites of wildlife. Bennett subsequently worked there as a research assistant during the summers of his undergraduate course. During his first summer, one of his tasks was making blood smears from birds, which he stained and examined. Prof. Fallis noted that Bennett showed a capacity for responsibility and original research. During his three summers at ORF's Wildlife Station he gained much experience working with haematozoa, black flies, biting midges and mosquitoes (Fallis, 1993a).

Following his graduation in 1953, Bennett enrolled in the School of Graduate Studies at the University of Toronto to study for a Masters degree under the supervision of Fallis. His research project was to expand an interest developed during his third undergraduate year of study, into the life history of the rodent bot fly, *Cuterebra emasculator*, a common parasite of chipmunks in Algonquin Park (Anderson, 1996). Receiving his Master of Science degree in 1954, he continued his association with ORF, proceeding immediately to PhD studies on a hitherto neglected group of flies, the Protocalliphoridae whose larvae parasitise nestling birds — often to the detriment of the birds. He looked for birds' nests high in trees, under bridges and in the rafters of old

buildings, altogether examining 4,781 nests of 110 species of birds. He found larvae of 20 species of *Protocalliphora* in both Ontario and Utah, some of which were new species (Anderson, 1996). A senior entomologist with the United States Department of Agriculture, Dr Curtis Sabrosky, was collecting data on the taxonomy and distribution of protocalliphorids in the United States and suggested that the results of their combined efforts would be most useful. Awarded his PhD in 1957, a major part of his work was incorporated in the book *Bird Blow Flies*, a combined publication of Sabrosky, Bennett and Whitworth (1989), with the taxonomy of the Protocalliphoridae having been clarified in the intervening years.

On completion of his doctoral degree in 1957, Bennett was appointed to the staff of ORF where he remained until 1966. He and Fallis collaborated on many important studies on the development and transmission of species of *Leucocytozoon* (see Fallis *et al.*, 1955; Fallis & Bennett, 1953, 1958, 1959) *Trypanosoma* and *Haemoproteus* (see Fallis & Bennett, 1960a) of birds, their insect vectors (Fallis & Bennett, 1960b) and the feeding behaviour of those insects plus their attraction to different stimuli (Bennett & Fallis, 1959, 1960, 1971). Highlights of the collaborative research of Bennett and Fallis were the discovery that many haemosporidia were transmitted by ornithophilic blackflies (Simuliidae) (Fallis & Bennett, 1961b, 1962a, b, 1963, 1966; Bennett & Fallis 1971) or biting midges (Ceratopogonidae) (Fallis & Bennett, 1961b) which showed marked host preferences. Bennett and Fallis showed the importance of CO_2 (Fallis *et al.*, 1967) and chemicals from the preen gland in attracting simuliid vectors of *Leucocytozoon simondi* to waterfowl. Bennett pioneered investigations on the behaviour of louse flies (Hippoboscidae) which live on different kinds of birds (Bennett, 1961). He would climb 10 metre high trees to examine a bird's nest and he designed a new method of collecting flies after they had taken a blood meal from an animal or bird.

In 1963 he accepted the invitation of Dr Robert Coatney of the United States Public Health Service, to spend two years in Malaysia in a collaborative research program with the Malaysian Institute of Medical Research in Kuala Lumpur. Here Bennett conducted studies on the transmission, development and systematics of simian malaria which he suspected may be a zoonotic disease for humans (Bennett, Warren & Cheong, 1966c). To prove his point, he infected *Anopheles maculatus* with *Plasmodium cynomolgi* from a macaque monkey and then allowed the mosquito to feed on him. Subsequently contracting *P. cynomolgi*, he retained the infection for the rest of his life (Anderson, 1996). Whilst in Malaysia he published a number of significant papers with Dr McWilson Warren and others (Bennett & Warren, 1964, 1966a, b; Bennett *et al.*, 1963, 1966a; Bennett & Cheong, 1965). Furthermore, he developed a particular interest in avian malaria (Sandosham *et al.*, 1965). During this period, he and Professors Garnham and Fallis redefined the genera *Leucocytozoon* and *Haemoproteus* (Bennett *et al.*, 1968).

Returning to ORF in 1965, he departed when their Department of Parasitology was integrated with the Department of Parasitology at the University of Toronto's School of Hygiene. He accepted appointment as Senior Principal Research Scientist with CSIRO in Brisbane where he worked with Dr Roger Tatchell on the biology of the cattle tick *Boophilus microplus*, the Australian vector of bovine babesiosis and anaplasmosis. Bennett's publications were on the reproduction of *B. microplus* and bovine host resistance to the tick (Bennett, 1975).

Bennett returned to Canada in 1969 to take charge of the International Repository of Avian Blood Parasites of WHO's International Reference Centre for Avian Malaria Parasites (IRCAMP). Records in November 1969 comprised 14,300 bloodfilms representing 760 species of 81 avian families (WHO, 1967). These records included 24 species of avian *Plasmodium*, plus species of *Leucocytozoon, Parahaemoproteus, Haemoproteus* and *Trypanosoma*. Following establishment of the Research Unit of Vector Pathology at Memorial University in 1972 (Fallis, 1993a), Bennett was promoted to full Professor. He became Head of the re-named International Reference Centre for Avian Haematozoa (IRCAH) in 1975. From his initial appointment, Bennett devoted himself to building up the collection and the literature relating to it, analysing all available information and describing numerous new genera and species of blood parasites and reclassifying others. His ultimate goal was to describe and determine the host and the geographical distribution of the blood parasites of all the bird families in the world — a goal he very nearly achieved with the publication in 1982 and 1992 of his *Host-Parasite Catalogues of the Avian Haematozoa* (publ. Memorial University of Newfoundland). They contain lists of families, genera and species of birds, the geographical distribution

of these hosts and their blood parasites. In the 1982 catalogue, Bennett and co-authors sought to update the taxonomy and nomenclature of birds. Of the known 175 avian families, 3,816 bird species of 152 families had been examined for blood parasites. Of those 3,816 species examined, 2,593 (68%) harboured one or more species of blood parasite, the most frequently encountered haematozoan parasites being species of *Haemoproteus*. The second most frequent parasite infection (48%) was with microfilariae of avian filariids (Phylum Aschelminthes, Class Nematoda, Superfamily Filarioidea), followed by species of *Plasmodium* (41.5%), *Leucocytozoon* (39%) and *Trypanosoma* (30%). Others which occurred relatively infrequently were *Atoxoplasma, Babesia, Haemogregarina, Hepatozoon, Lankesterella* and *Toxoplasma*. The 1982 catalogue also lists those birds examined but with negative results and gives the authority for each citation. The 1992 catalogue includes records of blood smears of birds made at the IRCAH since publication of the previous one and includes Tables of type host of the parasite genera listed above, author, status and date of most recent revision of re-description of the species. Comprehensive bibliographies accompany both catalogues.

Bennett published 50 articles on the blood parasites of numerous bird families throughout the world, in some of which he described new genera and species. His papers on the phylogeny and global distribution of the Haemoproteidae, resulting from collaborative studies with colleagues in South and East Africa and other countries, are considered 'landmark' publications (Anderson, 1996).

Bennett's total publications as author and co-author number some 250 papers covering a diversity of topics. Considered to be an outstanding Canadian biologist, honours were accorded him for his extraordinary knowledge of natural history. In 1989 he was chosen by the Parasitology Section of the Canadian Society of Zoologists to receive the Wardle Medal for his contribution to Parasitology. The Memorial University of Newfoundland named him University Research Professor for the period 1991–1996, and in 1992 he presented the De Porte Lecture to the Department of Entomology at McGill University. The International Reference Centre for Avian Haematozoa to which he contributed so much is a unique and exceptional collection of avian haematozoa and a distinguished addition to the Queensland Museum.

DAVID BLAIR (1949–)

David Blair (Fig. 51) was born in Glasgow, Scotland, on 5 January 1949. He graduated from Glasgow University in 1971 with a BSc with Honours in Zoology. Having developed an interest in parasites and tropical diseases from his first-hand experience of these in West Africa, he elected to do doctoral studies in parasitology under the supervision of Professor Adrian Hopkins at Glasgow University. His project concerned the biology of strigeoid trematodes, metacercariae of which cause blindness in farmed trout. Awarded his PhD in 1974, Blair emigrated from Britain to Australia. In Townsville, Queensland, he was appointed to a tutorship in the Zoology Department of James Cook University where he remained until 1979 — the same year he became a naturalised Australian citizen.

Blair's research in Townsville focused on parasites of tropical Australia's wildlife, including the investigation of digeneans of dugongs, chelonians and crocodiles; the cestodes of fish; a paramphistome in a wallaby; and bird schistosomes. Through 1979 and 1980, Blair was a University of Queensland post-doctoral Fellow in the Department of Parasitology where he furthered his earlier taxonomic work. From 1989 to 1998 he was a lecturer in the Department of Zoology at the University of Canterbury, Christchurch New Zealand, where he developed a strong teaching program in parasitology.

A 12-month sabbatical at Imperial College in London working with Dr D.P. McManus heralded his move to molecular systematics of parasitic flatworms in which Blair was to become a world authority. Returning to James Cook University as a lecturer in 1989, Blair concentrated on the systematics and evolution of parasites rather than alpha taxonomy. In this he continued his collaboration with Dr D. McManus with many publications arising from their research.

Invited in 1995 to be part of a consortium of scientists at a new Tropical Medicine Research Centre based in Shanghai China, Blair was asked to establish a sound taxonomic basis for the lung flukes, genus *Paragonimus*, with 25 nominal species reported as occurring in China alone. Collaboration with scientists in Japan and Vietnam ensued, concentrating on the phylogeny and classification of lung flukes.

Blair's molecular taxonomy work has included research into evolutionary change and the influence of environmental and host factors. His studies on

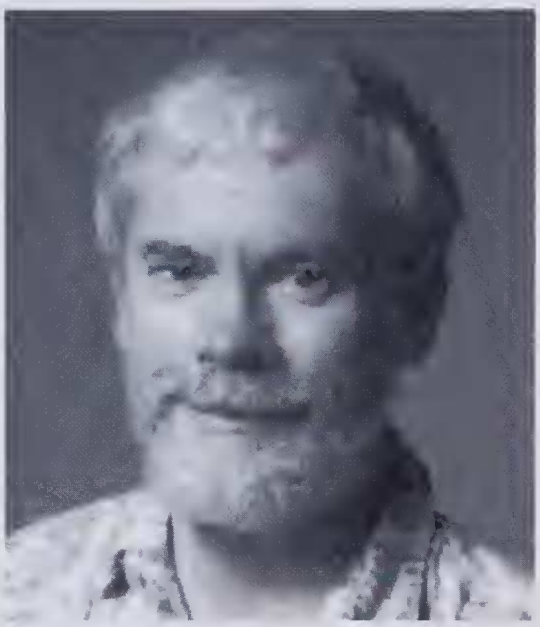

FIG. 51. David Blair

the secondary structure of ribosomal genes, and on comparative mitochondrial genomics, are featured in his contributed chapter to the book, *Parasitic Flatworms* (Blair, 2006). Additionally, he has contributed 11 chapters in Volume 2 of the recent series, *Keys to Trematoda*, published in 2005 by Commonwealth Agricultural Bureau International (CABI). He is currently preparing seven chapters for Volume 3.

Blair has authored 141 journal articles and 19 book chapters. As well as numerous new genera and species he has proposed two new families, Labicolidae Blair, 1979, and Balanotaenidae Mackiewicz & Blair, 1978.

Blair has supervised to graduation, 8 Honours students and 17 PhD students. Since 1989 he has attracted research funding totalling $2.8 million and has been immortalised with the following patronyms.

Moniligerum blairi Dailey, Vogelbein & Forrester, 1998 (Digenea; Opisthotrematidae).

Dujardinascaris blairi Sprent, McKeown & Cremin, 1998 (Nematoda: Ascaridoidea).

ANTON BREINL (1880–1944)

Anton Breinl (Fig. 52) was born in Vienna in 1880. Of Sudetan German origin, his family lived in the town of Graslitz in Bohemia, where they were engaged in the manufacture of wooden musical instruments and lace (Douglas, 1977b).

Breinl graduated in medicine from the University of Prague in 1904 and in May the same year went to The School of Tropical Medicine in Liverpool to study for a certificate in tropical health. Earning this award on 31 July 1904, his certificate was signed by the Professor of Tropical Medicine, Sir Ronald Ross (Ross earned a Nobel Prize for first establishing the life cycle of avian malaria and demonstrating that it is mosquito-borne (Foster, 1965)). Breinl was elected the J.W. Garrett International Fellow of the University of Liverpool between 1904 and 1907, and was able to work with Dr H. Wolferston Thomas researching trypanosomiasis. In August 1905, Breinl accompanied Thomas on an expedition up the Amazon River in Brazil to investigate yellow fever. There had been many deaths in this region, and the particular strain occurring there had a mortality rate of 95 percent. Both Thomas and Breinl contracted the disease in Manaos, and while both recovered, Breinl had been severely affected and only spent six months in Brazil (Douglas, 1977b).

In 1907, after their return to Liverpool, Thomas and Breinl sought to find a treatment for human trypanosomiasis ('sleeping sickness'). The aetiology and transmission of one species of human trypanosomiasis had been established only four years earlier by African scientists (Foster, 1965). The explorer David Livingston had demonstrated that 'nagana', the trypanosomiasis of wild game and of livestock, could be successfully treated with an inorganic arsenical. This led Thomas to experiment with the organic pentavalent arsenical 'Atoxyl', a product that had been used with some success since 1900 in the treatment of skin diseases and anaemia (Douglas, 1977b). Thomas and Breinl together investigated this drug's toxicity in humans, and found it to be an effective cure against the disease (Boyce & Breinl, 1908), leading to its broad usage thenceforth (Douglas, 1977b). Indeed, during this period Breinl himself fell prey to trypanosomiasis, and was the first European to be cured by using Atoxyl (Priestley, 1944). It was also in 1907 that Paul Ehrlich[25] revolutionised the treatment of syphilis (a systemic infection by a spirochaete, *Treponema pallidum*) with his trivalent arsenical, Salvarsan (606). Earlier, he had shown a red benzedine dye, 'trypan red', was an effective treatment for animal trypanosomiasis, and while this was also tried, with some success, in treating humans in Africa (Marquardt, 1949), it was Atoxyl which

proved the most effective treatment. Paul Ehrlich wrote a personal reference in support of Breinl's application for the position of Director of the Australian Institute for Tropical Medicine (AITM) at Townsville, speaking of him as '[...]onc of the leaders in modern chemotherapeutic work' (QIMR archival records, 1909).

Breinl took up appointment in Townsvillc on 1st January 1910. Breinl's first Institute in Townsville comprised a three roomed, iron-roofed, timber building measuring 10m × 6m, previously quarters for hospital wardsmen. At his official welcome by thc Queensland braneh of thc British Medical Association in Brisbane, in December 1910, Breinl expressed the hopc that the Institute would be able to enlargc the scope of its activities, and eventually be able to offer tcaching. He was also fortunate to gain the support of Prof. W.A. Osborne, Professor of Physiology, University of Melbourne, and of Dr J.S.C. Elkington, the Commissioner of Public Health for Queensland. Elkington lobbied the AITM Committee for an increased subsidy from the Federal Government to expand activities, and provide a new laboratory and animal house. In 1912, Breinl was given authority to draw up plans for a new institute, and allowed to appoint three new research staff, Dr W. Nicoll (parasitologist), Dr W.J. Young (biochemist), and Dr H. Priestley (bacteriologist). An entomologist, F.W. Taylor, had already joined the AITM staff in April 1911 (Douglas, 1977b).

Breinl made two journcys as far north as the Torres Strait, to acquaint himself with the diseases prevalent in his jurisdiction. In 1911, he visited the Northern Territory to report on prevailing medical conditions, and in 1912 and 1913 he investigated various regions in New Guinea. The expansion of his laboratory facilities and scientific staff allowed research into many aspects of tropical disease, as well as investigations into parasites of both native fauna and domestic animals.

In May 1914, Breinl became an Australian citizen, but as a German-speaker he was a target for racial intolerance because of the 1914–1918 war with Germany. During that war, in addition to carrying on his duties as Director of the AITM, Breinl acted in a voluntary capacity as the Superintendent of the Townsville Hospital after the incumbent enlisted in the war effort. He established a fine reputation for his successful treatment of malaria of servicemen from New Guinea. On three separate occasions, he volunteered the services of himself and his staff to the military authorities, but his offers were rejected (Douglas, 1977c).

FIG. 52. Dr Anton Breinl.

In April 1919, at the age of 38, Breinl married a nursing sister at the Townsville Hospital, Miss D. Lambton. She bore him twin sons, both of whom became doctors.

After the war, Breinl lost some of his scientific colleagues to academia: Dr H. Priestley became Professor of Bacteriology at the University of Sydney, and Dr W.J. Young, became Professor of Biochemistry at the University of Melbourne (Douglas, 1977b). Breinl was just beginning to resuscitatc the AITM, when he came under professional attack from Dr J.H.C. Cumpston, Chief of the Commonwealth Quarantine Medical Service. Mrs Breinl held that her husband was treated in such an abominable manner that he was forced to resign from thc AITM (Douglas, 1977c). It is generally believed that the attack on Breinl was largely the result of the xenophobia of the period, however Breinl also posed a stumbling block to Cumpston's plans to become thc first Director-General of Health in the new Commonwealth Department of Health, established in March 1921. Thc new Department's activities would have a major northern focus, with the AITM in Townsville playing an important role. The Commonwealth was also now responsible for what had been German New Guinea, as a mandated territory of the League of Nations. According to Sir Raphael Cilento, it was Cumpston's intention that the Commonwealth Department of Health should be establishcd 'with far-reaching potentialities in Tropical Australia and German New Guinea, and Breinl, as a German-speaking alien [sic][...]' would have been an embarrassment. Mrs Breinl contended, quite bitterly, that Cumpston had to get rid of Breinl in order to move the AITM to Sydney (Douglas, 1977c).

It is obvious, from what little documentation remains, that his position was made completely untenable by unfair and unjust criticisms of

his achievements as Director of the AITM. Furthermore, Cumpston advised Breinl that on the expiry of his contract on 1 June 1920, it would be renewed on an annual basis and subject to termination at six months' notice on either side. With no security of tenure, Breinl resigned on 30 October 1920, and commenced private practice in Townsville. One of his last major professional duties was to deliver the opening address at the 11th session of the Australasian Medical Congress in Brisbane, on 27 August 1920. Entitled 'Figures and facts regarding health and disease in Northern Australia influencing its permanent settlement by a white race', Breinl's paper concluded that 'investigations carried out (over the past 11 years) had not brought to light any facts indicating that health and disease as prevailing in North Queensland should make permanent settlement by a white race impossible' (Douglas, 1977c).

Breinl always regarded himself as a medical scientist, but acknowledged it was easier to make an adequate living practising clinical medicine. His popularity in Townsville guaranteed a large medical practice, and he continued working until shortly before his death, at 64, from renal failure (Douglas, 1977c).

MALCOLM STEWART BRYANT (1958–)

Malcolm ('Mal') Bryant (Fig. 64) was born in Gayndah, Queensland in 1958. He first worked as a Cadet Radiographer at the Department of Veterans Affairs Repatriation General Hospital in Greenslopes, Brisbane, while undertaking an Associate Diploma of Applied Science in Diagnostic Radiography at the Queensland Institute of Technology. After graduating in 1980, he was promoted to Radiographer Grade I. A Diploma of Applied Science (Diagnostic Radiography) followed in 1981, and in 1984 he was further promoted to Radiographer Grade II. In 1985 he was appointed Senior Radiographer in charge of the Digital Angiography Procedure room at the Holy Spirit Hospital, Brisbane. This became a casual position in 1989 when he enrolled in a fulltime Bachelor of Science course at the University of Queensland (UQ), majoring in Parasitology.

Bryant graduated BSc in 1991, but continued with an Honours year in marine parasitology supervised by Dr R.J.G. Lester. He was awarded First Class Honours in1992 (Bryant, 1992). He was then awarded a UQ Postgraduate Research Scholarship to undertake a PhD, investigating the immune response of barramundi, an important cultured fish species. He maintained his position as casual radiographer at the Holy Spirit Hospital while studying between 1989 and 1998. Between 1994 and 1997 he also worked as an assistant for other researchers in the Department of Parasitology, first at Heron Island Research Station, then at Lizard Island Research Station where he collected ectoparasites from reef fish. Other duties included collection of marine and freshwater animals for use in undergraduate practical classes.

Bryant was awarded his PhD in June 1999 (Bryant, 1999). During 1998 he worked in an honorary capacity as technical assistant to Dr Lester Cannon, Senior Curator of Worms at the Queensland Museum, assisting with collection maintenance and specimen cataloguing. Following the resignation of Cannon's incumbent Senior Technical Officer, Kim Sewell, in 1998, Bryant was appointed as Museum Technician, Technical Officer 2, working with Cannon and Dr Robert Adlard, Curator of Protozoa. He was promoted to Senior Museum Technician in 1999. His knowledge of digital imaging modalities gained whilst a radiographer, are of value in digital image capture and scanning electron microscopy (see, for example, the illustration of cuticular morphology of some species of Nematomorpha in Bryant & Cannon, 1999). He is responsible for the maintenance and updating of the Worms and ASPIC databases, and for storage and conservation of the collection.

LESTER ROBERT GLEN CANNON (1940–)

Lester Cannon (Fig. 66) was born in St Neot's, Huntingdon, England, on 4 September 1940. His parents emigrated to Australia on 1 January 1950 and settled in Redcliffe outside Brisbane. Matriculating in 1959, he was awarded a scholarship by the Queensland Department of Agriculture and Stock that supported him through undergraduate studies in Zoology at the University of Queensland from 1960 to 1962.

Cannon was greatly influenced by Dr J.C. (John) Pearson, a digenean trematodologist in the Department of Parasitology, and would have liked to study flatworms of wild birds. However his scholarship required him to work for the Queensland government, for at least four years, as a veterinary parasitologist, and in this capacity he was assigned to the Animal Research Institute (ARI) at Yeerongpilly, where he worked as an assistant to Pat O'Sullivan learning diagnostic skills. Les Newton, the head of the Pathology Branch at ARI set Cannon to work researching

coccidiosis in chickens. Cannon discovered that two separate parasite infections were synergistic — the presence of coccidia organisms promoted greater numbers of roundworm, *Ascaridia galli*, to mature. He published his first paper on this finding (Cannon, 1966). Wanting to capitalise on his work in coccidia, Cannon enrolled for a MSc at the University of Queensland under the protozoologist Dr H.M.D. (Duncan) Hoyte, but elected to study infections of coccidia in native reptiles rather than in domestic chickens.

Cannon desperately wanted to study wildlife parasitology, so after one year at the ARI he broke his bond — at considerable expense —to become a tutor in the Zoology Department of the University of Queensland. As he had initially undertaken work towards his MSc, he was able to enrol in the second year of the two-year part-time Zoology Department Honours program, and though remaining under Hoyte's supervision, he was to graduate with a Zoology Honours IIA.

Being in considerable debt following his broken bond with the Queensland Government, in 1965 Cannon accepted a paid PhD student position working with Douglas Moorhouse in the Department of Parasitology, on life cycles of *Onchocerca gibsoni*, a parasite of cattle. His second publication, prepared with the help of Eric Reye, a biting midge expert in the Department of Entomology (Cannon & Reye, 1966), was on the larval breeding grounds of *Culicoides brevitarsis*, the suspected vector of *O. gibsoni*. Cannon found Moorhouse's supervision intrusive, and realised he would be unable to complete his PhD under his direction. Prof. J.F.A. Sprent, the Head of Parasitology, offered him a change of supervisor, but Cannon chose instead to pursue his interests in wildlife parasitology. He was impressed with the ecological approach with which Dr Murray Fallis, Head of the Ontario Research Foundation (ORF), had imbued his graduate student John Pearson. Since Pearson had returned to ORF on sabbatical in 1966, Cannon contacted him to enquire if there was a possibility of acquiring a scholarship to undertake PhD studies at ORF. He was subsequently granted a pre-doctoral Health Science Award at the University of Toronto for the year 1967. Cannon flew to Toronto in July 1966. Helminthologist Dr Reino ('Ray') Freeman became his supervisor for a project studying trematodes in fish, although knowing of his research on coccidia, Prof. Murray Fallis tried to interest Cannon in avian haematozoa.

ONTARIO, CANADA. For Cannon's first winter in Toronto he worked on the top floor of the ORF building (Fig. 14) in Queen's Park. Initially he undertook field work in Lake Sasajewun in Algonquin Park, but the following summer he worked at Lake Opeongo on taxonomy and ecology of digenean life cycles in the fish, *Perca flavescens*. To finance his PhD studies from 1967–1969, Cannon was awarded an Ontario graduate scholarship by the University of Toronto; this was followed from 1969 to 1970, with the National Research Council of Canada Bursary. In the winter of 1967, while Cannon was working in the Zoology Department of the University of Toronto, he met his future wife, Christine Deane. Christine who had worked on planarians at the University of Leicester, England was an MSc student of David Mettrick's. Lester and Christine married in August of 1968.

In the winter of 1968 Cannon was transferred to the School of Hygiene (Fig. 15) and following completion of field work in 1969, back to the Department of Zoology where he completed his thesis in June 1970. He was immediately awarded a Ford Foundation Post-doctoral Fellowship in Ecology at the University of California in Santa Barbara (1970–1971) to work with Joe Connell, a renowned ecologist working in one of the foremost schools of ecology at that time.

CALIFORNIA, USA. Cannon was interested in the concept of the ecological cost of morbidity. In a short pilot study Cannon took larvae of the flour beetle, *Tribolium confusum*, and fed them eggs of the tapeworm, *Hymenolepis diminuta*. After three to four months the data showed that *Hymenolepis* infection affects the duration of larval life, success at pupation, duration of pupal life, and success at eclosion to adult. Furthermore, there were teratogenic effects on those beetles which did reach adulthood. However because this was only a 'pilot study' it was never published.

At the end of his post-doctoral year in Santa Barbara, Cannon, now with a wife and two daughters, wanted very much to return to Australia. The Australian Government was offering, for the first time, five Queen's Fellowships in Marine Science, that unlike normal Fellowships, were open to international competition. Cannon applied and was succesful.

CANNON RETURNS TO QUEENSLAND. The Queen's Fellowship was for two years from August 1971 to December 1973. Originally Cannon was to go to the newly established

Australian Institute of Marine Science (AIMS) near Townsville, but instead, he opted for the Department of Parasitology at the University of Queensland. Stimulated by Pearson's publication on the life cycle of the trematode *Paucivitellosis fragilis* showing cercariae in the snail *Cerithium moniliferum* (Pearson, 1968), Cannon wished to investigate the impact which that trematode had on the snail population, but the problem proved to be too complex because numerous other digeneans were also present in the snails. Instead he published papers on the breeding biology of the snail, the diversity of cercariae, and the ecology of infections in *Cerithium* on Heron Island (Cannon, 1975; 1978b; 1979). During his Fellowship Cannon also did some teaching in the Department of Parasitology, and collaborated with Ben Cropp in the making of a film, 'Strange Partners of the Coral Reef' (Cropp & Cannon, 1973). Cannon was very keen to introduce students to the wonders of symbioses, and to emphasise how blurred are the boundaries with parasitism. In the laboratory, he devised some exciting experiments using cleaner fishes, and clown fish with anemones. He supervised an Honours student, Bill Phillips, on the taxonomy and ecology of sacculinids, and an MSc student, Ross Bishop, on the impact of *Sacculina* parasitism on crab behaviour. Cannon shared a room with Klaus Rohde[26] who was investigating aspidogastrid worms, and 'clumping' behaviour of snails on the beach rock at Heron Is. At the end of his Queen's Fellowship, Cannon followed the advice of Prof. Sprent to apply for a research grant into biological control of the Crown of Thorns starfish.

THE CROWN OF THORNS STARFISH. In the late 1960s and early 1970s there was a surge in interest in marine science in Australia. Prof. Cyril Burdon-Jones, Foundation Professor of Marine Biology at James Cook University, was a pioneer force for the establishment of the Australian Institute of Marine Science. At this time also, the coral-eating Crown of Thorns starfish, *Acanthaster planci*, rose to prominence as a putative major threat to the very existence of the Great Barrier Reef. In response, the Commonwealth Government's Department of Education and Science set up the Advisory Committee into Research on the Crown of Thorns starfish, with funding for research available. Cannon successfully applied for two years' funding to investigate possible biological control agents (Cannon, 1973b, 1978c), and was appointed as post-doctoral Fellow in the Department of Parasitology. This was also the impetus to establish marine parasitology in the Department, including the establishment of experimental aquaria at the Veterinary Farm precinct at Pinjarra Hills (Fig. 24).

ONGOING CAREER. In 1975, Prof. Sprent supplied Cannon with funding to investigate ascaridoid worms in fish (Cannon, 1975, 1977a, b) and in molluscs (Cannon, 1978a). Working with Greg Berry a PhD student of Sprent's, it was found that *Sulcascaris* nematodes, a cause of concern in the scallop industry, mature in turtles (Berry & Cannon, 1981).

In June/July 1976, the Fishing Industry Research Trust (FIRTA) indicated it would provide money to the Department of Parasitology on the *proviso* that the University of Queensland give Cannon a permanent position to ensure the continuation of the study of marine parasitology. At that time, the University of Queensland Senate was not prepared to accept demands ensuant from funding grants. Cannon, with a wife and two daughters to support, could not contemplate continuing his precarious reliance on ephemeral 'soft money'. Accordingly, he successfully applied for the position of Curator of Lower Invertebrates at the Queensland Museum, taking up appointment in November 1976. Here he turned his attention to the Turbellaria, especially those that are symbiotic or parasitic.

Following the Sixth International Congress of Parasitology held at the University of Queensland in 1986, Cannon began to conscientiously build the parasitology collections at the Queensland Museum. The acquisition of IRCAH at the end of 1995, along with other important collections, means that the Queensland Museum collection is now one of the most important in the world.

Between 1977 and 1979 Cannon was treasurer of the Great Barrier Reef Committee and in 1990 was elected an Honorary Research Advisor to the Department of Parasitology at the University of Queensland. In 1991 he was elected Fellow of the Australian Institute of Biology, and in 1996 he was Convenor of the Eighth International Symposium on the Biology of the Turbellaria (ISBT VIII) in Brisbane. He has been a member of a number of Editorial Advisory Committees including the Australian Biological Resources Survey between 1994 and 1997.

Cannon's initiative in developing ASPIC, a database of Australian parasitology collections, has further enhanced his standing in the international scientific community and at the annual general

meeting of the Australian Society for Parasitology in 1999, he was elected a Fellow of that Society.

His publications to date number well over 100 articles in refereed journals and 25 popular articles. He has made numerous Symposium presentations and written several popular publications, including his book produced with M. Goyen *Exploring Australia's Great Barrier Reef* published in 1989, which he has since released on CD-ROM. Also now on CD-ROM are his books on *Northern Australian Sea Cucumbers*, and *Turbellaria of the World. A guide to Families and Genera.*

In 1998 Cannon was awarded a Colliver[27] Scholarship by the Queensland Museum to travel throughout the Americas, to enable him to acquire an overview of approximately half the world's collections of parasites and their curation procedures. Lester Cannon officially retired in June of 2003.

In January 2004 Cannon was awarded a Queensland Museum Medal '[...] in recognition of his prestigious career, distinguished by scientific research excellence and the significant role he has played as a respected ambassador for science and the Queensland Museum. [...] He performed his position of Senior Curator: Worms with great distinction and dedication [and] contributed significantly to many facets of the Museum's work and its reputation as an authoritative educational institution. [...] Largely due to his initiative, the Queensland Museum collection of parasitological material has grown from approximately 200 to in excess of 100,000 specimens, placing this collection among the top five internationally[...] He has contributed greatly to the development of early career scientists through employment, post-graduate supervision and in his position as Research Advisor to The University of Queensland [...]'.

ROBERT C. COLBRAN (1926–)

Robert ('Bob') Colbran (Fig. 53) was born in Brisbane on 3 August 1926. After completing High School at St Laurence's College, South Brisbane in 1943, he undertook a degree in Agricultural Science at the University of Queensland. After graduating in 1948, Colbran accepted a position as horticulturalist at the CSIR (now CSIRO) field station at Applethorpe, in the centre of the Queensland apple industry. His role was to determine why apple trees often failed to grow satisfactorily when they were replanted on land that had previously grown apples. During his initial investigations, he noticed large numbers of nematodes in roots that had been sectioned and stained. Although he had never previously seen a nematode, this observation sparked a lifelong interest in nematodes and their role in inciting plant disease.

Colbran's initial observations were made at a time when interest in nematodes was in its infancy. Soil fumigants developed during World War II enabled nematodes to be controlled for the first time and their use provided evidence that nematodes were causing significant damage on many crops. Colbran therefore decided to devote his career to nematology. To further those interests he joined the Entomology Branch of the Queensland Department of Agriculture and Stock.

After a few years working as a nematologist, Colbran was awarded a Rockefeller Fellowship, which allowed him to spend 1958 at the University of California in Davis. At that time, UC Davis was a major centre of nematological research and the visit enabled Colbran to meet most of the world's eminent nematologists and further his special interest in nematode taxonomy. On his return, he completed his doctoral studies as an external student and was awarded a PhD by the University of Queensland in 1962.

Colbran worked at a time when little was known about the nematode fauna in Queensland soils. His pioneering taxonomic studies on plant-parasitic nematodes therefore laid the foundation to our understanding of the distribution and importance of this group of nematodes. He described many new species, but because many of the descriptions were published in the *Queensland Journal of Agricultural and Animal Sciences*, most overseas nematologists were not aware of them. One example was the name *Trichodorus christei*, which was widely used for an economically important species, by American nematologists in the 1950s and 60s. Later it was realised that Colbran's description of *Trichodorus minor* in 1956 had taxonomic priority.

The extent of Colbran's early studies on the taxonomy and distribution of nematodes in Queensland is apparent in his 1964 publication ('Studies in Plant and Soil Nematodes. Queensland records of the Order Tylenchida and the genera *Trichodorus* and *Xiphinema*.' *Queensland Journal of Agricultural and Animal Sciences* 21). At the turn of the century 36 years later, his publication

still covered more than 95 percent of the plant-parasitic nematodes known in Queensland.

During his career, Colbran made many site collections, as well as an extensive collection of slides. Because of its importance in recording the nematode fauna in Queensland, it was transferred to the Queensland Museum in 1992.

Although Colbran had a keen interest in nematode taxonomy, he also made an enormous contribution to practical issues related to the control of nematodes in tropical and sub-tropical crops. Many of the control measures used today in crops such as banana, pineapple, ginger and apples are based on the results of experimcnts done by Colbran in the 1960s and 70s. In 1976, he was awarded a medal from the Australian Institute of Agricultural Science for his contribution to nematology.

Colbran spent the last 10 years of his career as a science administrator and for most of that time he was Director of Plant Pathology Branch, Department of Primary Industries. On his retirement in the late 1980s he was responsible for a research group comprising about 25 scientists and 35 administrative and technical staff.

FIG 53. Dr R. Colbran.

Bob Colbran was typical of the generation of nematologists who worked in Australia during the immediate post-war period. Not only did he describe many nematodes that were new to science, but he also developed practical control measures for a poorly understood group of pests that were causing major problems in some crops. At a time when most nematologists worked in the temperate regions of Europe and North America, Colbran played a pioneering role in a more tropical environment. His contribution to our understanding of the distribution, pathogenicity and control of nematodes in sub-tropical and tropical crops therefore had a major impact throughout the warmer regions of the world.

THOMAS HERBERT CRIBB (1960–)

Tom Cribb (Fig. 35) was born in Brisbane on 15 August 1960. He graduated from the University of Queensland with 1st Class Honours in Parasitology in 1982, and was awarded a University Medal for outstanding academic performance. He then undertook his PhD studying digenean trematodes under the supervision of Prof. John C. Pearson, and this was awarded in 1986.

Cribb won a CSIRO post-doctoral award in the period 1986–1988, and spent one year studying at the Natural History Museum in London, where he worked with Dr Rodney Bray. In 1988 Cribb then received a University of Queensland post-doctoral research fellowship, to work with Dr David Spratt in CSIRO's Wildlife and Ecology Section in Canberra. Awarded a QEII Research Fellowship in December 1989, Cribb worked at the Queensland Museum, with Dr Lester Cannon, until August 1992 when he became a Lecturer in helminthology at the University of Queensland, following the retirement of his mentor, Prof. John Pearson. Appointed Senior Lecturer in Helminthology in 1996 he was promoted to Associate Professor in 2001.

Since joining the University, Cribb has served on the Biological Science Curriculum Committee (1992–1995), and initiated training of tutors in the Department of Parasitology. In 1997, he served on the Faculty of Biological and Chemical Sciences (BACS) Studies Committee; in 2001 on the Departmental postgraduate student committee and in the period 2002–2003, he co-ordinated the Bachelor of Marine Studies program. He has supervised many PhD and MSc students and over 30 Honours students. Since 1990, Cribb has attracted research grants of more than $1.365 million. He has been a keynote speaker at eight

professional conferences since 1997, one of these being the Ninth International Congress of Parasitology (ICOPA IX).

Cribb has published 175 papers in refereed journals and identified nearly 200 new species (including nematodes, acanthocephalans and cestodes), and 40 new genera.

ROBERT DOMROW (1931–)

Robert (Bob) Domrow (Fig. 41) is one of the world's leading acarologists, his specialty being parasitic mites (Order Acarina). He was born on 4 January 1931. He attended Brisbane State High School from 1945 to 1948, achieving a high academic standard, and matriculating for all faculties at the University of Qucensland excepting Law and Architecture.

In December 1948, Domrow wrote to the Secretary of the Queensland Institute of Medical Research (QIMR) applying for their cadetship as advertised in the *Courier Mail* newspaper, and on 9 February 1949, Domrow was appointed a 'cadet on probation' at a salary of £205 per annum. In February 1950, sponsored by the QIMR, he enrolled as a part-time student in Zoology, at the University of Queensland. In June of that year his cadetship was confirmed, and he received an increase in salary of £80 p.a. Domrow's appointment progressed from cadetship, to Assistant, to Research Officer in July 1952.

During the long end-of-year University vacation in 1953, Domrow was sent by QIMR to be tutored by Mr Herbert Womersley, a parasitic mite specialist at the South Australian Museum in Adelaide (see earlier). He graduated with a BSc in Decembcr 1954, and was promoted to Assistant Research Officer. Wishing to extend his knowledge of Latin studied during high school, in 1955 he enrolled to study classics at the University of Queensland and graduated Bachelor of Arts in 1958.

Along with some other foreign scientists, Domrow was sponsored by the National Institute of Health (USA) to attend the 10th Pacific Science Congress being held in Honolulu between 21 August and 6 September 1961. Here he was able to meet and converse with other active international scientists working on mites of medical importance, including Dr Audy's group of mite researchers working on the Malaysian-Australasian fauna. Details of his productive career in mite taxonomy at the QIMR are contained in the 'Collections' section of the main text.

In September 1986, Domrow was seconded to the Queensland Museum, although his salary continued to be paid by the QIMR. The QIMR had altered its research focus away from parasitology and arbovirus research, and felt that the Museum would be a better environment to foster Domrow's work. Domrow remained at the Queensland Museum until his voluntary retirement on 30 April 1988, but maintained an honorary association until the end of 1990 in order to complete projects on trombidiform and sarcoptiform mites, such work being funded by ARGS and ABRS respectively. During a productive career, Domrow documented a total of 13 new genera, 3 new sub-genera and 301 new species.

ALBERT MURRAY FALLIS (1907–2003)

Professor Fallis' career was entwined with the development and success of the veterinary parasitology program at the Ontario Research Foundation (ORF), so we here also include some relevant historical background of ORF and its early administrators.

Murray Fallis (Fig. 54) was born in Minto, Ontario, in 1907. He had a short two-year career as a schoolteacher at Elma, Ontario, before enrolling at the University of Toronto in 1928, and obtaining his BA in 1932 (Anderson, 1986). In his final undergraduate year, Fallis came under the influence of the distinguished entomologist, Edward M. Walker, the Professor of Invertebrate Zoology, who provided a medically oriented course in parasitology (Fallis, 1993a). Fallis accepted a fellowship at ORF, supervised by Walker but to study with Dr Seymour Hadwen, the Director of Veterinary Science. Fallis was profoundly influenced by Hadwen (Anderson, 1986), so it is pertinent to provide some background on this scientist and his diversity of interests. Seymour Hadwen graduated in Veterinary Science from McGill University in 1902. In 1906 he studied entomology with Prof. Neustead at the Liverpool School of Tropical Medicine and subsequently went to Cambridge to study with Prof. G.H.F. Nuttall, an expert on ixodid ticks (Nuttall, 1911). Inviting Hadwen to work with him on canine piroplasmosis, Hadwen selected as a prophylactic, the drug 'trypanblau' with known efficacy against trypanosomes. So successful was this drug in helping dogs survive the crisis stage of the disease (Nuttall & Hadwen, 1909a), that Nuttall decided to trial the drug on cattle

suffering from East Coast Fever (theileriosis) and again, trypanblau proved effective (Nuttall & Hadwen, 1909b). Moving to the Federal Research Laboratory at Agassiz, British Columbia, Hadwen's ongoing studies on Canadian insects of medical and veterinary importance, became the foundation for all future work in that country (Reigert, 1980). Hadwen also established an enviable reputation for his extensive research in veterinary parasitology and vector-borne parasitic disease. Prior to his appointment in 1929 as Director of Veterinary Services at the newly established ORF, Hadwen had been Research Professor of Animal Diseases at the University of Saskatchewan. He was greatly admired by Fallis, who referred to him as '[...] the kind and gentle Hadwen' (Fallis, 1993a).

Fallis also came under the influence of the ORF's founding director, Dr H.B. Speakman. Speakman not only founded research on parasites at ORF, but also imbued the institution with his great love of scholarship. According to Fallis (pers. comm.) Speakman encouraged research but gauged success on the quality of the work, not just by the number of papers published. From 1932 to 1947 Fallis was a Research Fellow at ORF. Following the awarding of his PhD in 1937 (partly published, see Fallis, 1938), he was invited by Prof. D.T. Fraser, Professor of Preventive Medicine at the University of Toronto, to give a short course on parasitology to the Diploma of Tropical Health class in the Department of Hygiene and Preventive Medicine (Craigie, 1965). This association with the Department of Hygiene was to continue until Fallis' retirement in 1975 (Anderson, 1986).

FIG. 54. A. Murray Fallis. (Courtesy Dr. Sherwin Desser).

In the early 1960s ORF planned to move to the suburbs, and Fallis, who had taken over as Head of the Department of Parasitology on Hadwen's retirement in 1947 (Anderson, 1986), accepted an offer by the director of the School of Hygiene, Dr W.R. Stadelman, to locate ORF's Department of Parasitology at the University of Toronto. The move included the parasitologists Fallis, Freeman and Wright, and ORF's equipment and extensive library. The School of Hygiene also provided a 'phasing-in' grant, plus a substantial sum that Fallis could use at his discretion to foster the interests of the department. This enabled Fallis to bring eminent scientists to the department as Visiting Professors for two or three month periods. Invitees included such notables as Professors P.C.C. Garnham and J. Baker from the London School of Hygiene and Tropical Medicine, W.H.R. Lumsden from the University of Edinburgh, D. Heyneman of the Hooper Foundation in California, and E. Fife of the United States Department of Health, Education and Welfare in Washington D.C. (Fallis, 1993a).

Most students working at ORF were registered at the University of Toronto in the Department of Zoology or the School of Hygiene, but sometimes in both. Anderson (1986) considers that such students were doubly blessed in having available a superb faculty at Toronto and the 'fatherly concern of Dr H.B. Speakman and that remarkable collection of scientists he ruled with a benevolent paternalism at ORF'.

In the 1940s, Fallis (1948b) investigated the effect of larval ascarids on guinea pigs. He pioneered the use of the Waring blender to break up tissues to release the nematode larvae — a technique still widely used by both plant nematologists and parasitologists (Anderson, 1986). Using experimental animals he studied the immunity associated with infection by the large human roundworm, *Ascaris lumbricoides*, and measured the big increase in eosinophils noting that pneumonia ensued in severe infections. Fallis considers this work to have been the forerunner of more sophisticated research on cellular immunity

successfully pursued by Dr J.F.A. Sprent, who joined ORF in 1947 and subsequently went to Queensland. Fallis (like Taileferro in Chicago) had to abandon his ascaridoid research when he developed severe allergies to *Ascaris* (Anderson, 1986). Instead, he turned his attention to sporozoans, in particular, the blood parasites of birds (Fallis, 1945, 1946), becoming an authority on *Leucocytozoon* (see Fallis, 1948a, 1950; Fallis & Hope, 1950; Fallis *et al.*, 1951), species of malaria-like parasites that cause fatal disease in birds.

In the 1950s and 1960s, Fallis and his students studied avian haematozoa at the Wildlife Research Station in Algonquin Park. One of his graduate students, Gordon Fraser Bennett (Fallis, Pearson & Bennett, 1954; Fallis, Anderson & Bennett, 1956), was later to become curator of the United Nations-sponsored International Research Centre for Avian Haematozoa at Memorial University, St Johns, Newfoundland (see part A). Fallis & Bennett (1958) demonstrated the transmission of *Leucocytozoon bonasae* to ruffled grouse by simuliid flies, and conclusively showed the involvement of ornithophilic simuliids in the transmission of other *Leucocytozoon* species. In addition to investigating the various vectors of *Leucocytozoon* (see Fallis & Wood, 1957; Fallis & Bennett, 1960b; Fallis & Bennett, 1962a), Fallis and his associates worked out the details of sporogony (Fallis & Bennett, 1960a, 1961b, 1962a, b; Desser & Fallis, 1967a, b; Khan & Fallis, 1971a), gametogony (Yang *et al.*, 1971; Desser *et al.*, 1976) and schizogony (Khan & Fallis, 1971b). These studies contributed significantly to our knowledge of the pathogenesis of avian haematozoa.

The behaviour of ornithophilic simuliids and the role of olfactory and visual stimuli (Fallis & Smith, 1964; Fallis *et al.*, 1967; Fallis, 1968; Bennett *et al.*, 1972; Fallis & Raybould, 1975) provided a comprehensive picture of the epizootiology of leucocytozoonosis which assisted WHO investigations into the vectors of human onchocerciasis or 'river blindness' in Africa (Anderson, 1986). The discovery of ornithophilic midges (Ceratopogonidae) as vectors of *Haemoproteus* (see Fallis & Wood, 1957; Fallis & Bennett, 1960b) elucidated the mode of transmission, sporogony and schizogony of *Haemoproteus* spp. (Fallis & Bennett, 1961a, b; Khan & Fallis, 1971a, 1971b). Additionally, studies by Fallis' group were carried out on *Trypanosoma* (see Fallis *et al.*, 1973).

Fallis made an outstanding personal contribution to our knowledge of blood parasites, but just as importantly, he left a legacy of highly trained and dedicated scientists who had the good fortune to carry out graduate studies at ORF under his supervision or co-supervision. Many achieved distinguished careers in their own right. Fallis commented to Cannon that his approach to teaching was to convey the thrill of discovery and to encourage a questioning mind, all the while paying attention to the ordered way in which various factors fit together to facilitate transmission and survival of parasites.

Dr Fallis was Head of the Department of Parasitology at ORF between 1947 and 1966 and continued in an executive capacity when the department was integrated with that of the School of Hygiene at the University of Toronto. He was elected Fellow of the Royal Society of Canada in 1958. He served as President of the Royal Canadian Institute (1955–1956), President of the Ontario Society of Biologists (1955–1956), Vice-President in 1970, and subsequently President of the American Society of Parasitologists — only the second Canadian to hold this office. In 1982 he was President of the Fifth International Congress of Parasitology held in Toronto. Over the years, he has served on several editorial boards dealing with parasitology (Anderson, 1986). Following his retirement in 1975, when he was elected Professor Emeritus of the University of Toronto, Fallis retained his enthusiasm for parasitology and followed with interest the research and careers of his many students. Anderson (1986) has described Fallis as one of the pioneers of veterinary parasitology in Canada — a scholar, teacher, scientist and innovator of techniques. In addition to his scientific publications he has also published historical articles on parasitology and parasitologists in Canada.

Australian scientists influenced by him, and who have attained positions of status and prestige, include J.C. Pearson, L.R.G. Cannon, D.M. Spratt and R.J.G. Lester, all of whom are reported in this account.

Albert Murray Fallis died on 8 July 2003 at the age of 97 years.

ALEXANDRE ARSENE GIRAULT (1884–1941)

Girault (Fig. 55) was born in Annapolis, Maryland, U.S.A., in 1884, of French descent. He died in penury in Queensland in 1941, having lived

and worked in Australia from 1911 to 1914, and then again from late 1917 until his death in 1941. In 1903 he graduated from the agricultural college of Virginia, the Virginia Polytechnic, and in 1904 began working with the United States Department of Agriculture in Washington, investigating insects of economic importance. In 1909 he transferred to the University of Illinois and it was here that his interest in chalcidoid parasitic wasps ('minute parasitic insects') began (Dahms, 1978).

In 1914 he moved to Australia to take up a position with the Queensland Department of Agriculture and Stock, specifically to work with the Queensland Bureau of Sugar Experimental Stations to study the sugar cane beetle (Scarabaeidae). Australia's relatively unstudied parasitic chalcidoid wasp fauna provided fertile ground for Girault, and from 1911 to 1914 he published prodigiously describing many new species. By January 1912 he had deposited 50 type specimens with the Queensland Museum. His desire to continue on the taxonomy of chalcidoids prompted him not to renew his contract with the Queensland government when it expired in 1914, giving his Queensland employers twelve months' notice of his intention to return to USA to focus on taxonomic work.

Girault's first major paper was published in Volume 1 of the *Memoirs of the Queensland Museum* (Girault, 1912). Girault's eccentric nature was evidenced by the 'dedications' which accompanied his papers. These rambling dissertations embraced his own philosophies on various issues, and had no bearing on the taxonomy of chalcidoid wasps. The museum's director, Hamlyn-Harris, tactfully suggested to Girault that his dedications be omitted, but Girault countered by arguing that he was endeavouring to emphasise the importance of taxonomy, and to change the way of thinking of other scientists who regarded it as '[...] isolated and unrelated to other work in science' (Dahms, 1978: 135). Nevertheless Girault did agree to having his dedications omitted.

In November 1914 Girault returned to the United States with his Australian wife. World economic depression resulting from the Great War brought financial restrictions. From 1915 he was employed by the US Department of Agriculture, in the Bureau of Entomology, but his desire to concentrate on taxonomy was subjugated to the practicality of economic entomology which he despised as not being 'pure science'. He was increasingly disliked by his colleagues for his personal attacks on economic entomologists (printed in his various privately published papers), whom he accused of 'prostituting their training' (Dahms, 1978: 144). He returned to Australia with his family in the latter part of 1917 with no prospects of employment, settling in Pentland, Queensland, where his wife's family resided. He applied to the Queensland Department of Agriculture and Stock for re-employment, but the Department had some reservations about Girault. As in the US, the Department needed entomologists who would concentrate on economic entomology, and specifically, to focus on cane grub investigations. During his earlier contract with them he had devoted a considerable amount of time to chalcidoid taxonomy, and his reason for resigning in 1914, 'to concentrate on taxonomy', did not inspire them with confidence that Girault would bend to their will. It was only following verbal assurances that he would devote *all* of his time to the work of the Sugar Bureau, that Girault was appointed on a temporary basis to work with Dr J.F. Illingsworth at Meringa Experimental Station. At £250 per annum, his salary was £150 less than he had been earning on his departure four years earlier! Girault continued working on the taxonomy of chalcidoids in his own time, using a microscope and hand-lens 'on loan' from the Meringa Station. However, his cavalier attitude to his paid employment was manifest in his disregard for submission of required weekly reports. In November 1918, Illingsworth informed the Department of his dissatisfaction with Girault's work, and in February 1919 requested Girault's dismissal (Dahms, 1978: 148–49). Girault gave vent to his ire by personally and childishly attacking Illingsworth in a privately published paper (Dahms, 1978).

So followed a hiatus in his paid employment as an entomologist. Girault supported his family through a variety of unsuccessful business ventures, continuing his chalcidoid studies with a microscope borrowed from a local physician. He continued to get the support of the Director of the Queensland Museum, by this time Heber Longman (Dahms, 1978: 148) who none-the-less chided Girault, in response to a somewhat terse communication from him, that '[...] surely many of your difficulties are of your own making[...]'. Girault's scientific papers were published in the *Memoirs* at the Museum's own expense, and periodically Longman supplied him with microscope slides, cover slips, pins, tags, glue and Canada balsam (Dahms, 1978: 151). However the Museum was unable to offer him employment, and in February 1922 he once more

applied to the Department of Agriculture and Stock. Fortuitously in November 1922, the Government Entomologist and Plant Pathologist, Henry Tryon, gained approval for the appointment of a trained entomologist, and Girault was appointed in February 1923 as Assistant Entomologist out of a field of thirteen applicants. His employment was reviewed at the end of 1923 and extended for another six months, and thereafter, until June 1927, reviewed every twelve months until Tryon's retirement heralded the arrival of Robert Veitch as Chief Government Entomologist Girault's contract was then reviewed six-monthly until June 1931 and then three-monthly. His application for permanent appointment was denied following a recommendation by Veitch in 1933, and in June 1935 his services were terminated. The reason stated was that he was still an American citizen, but his refusal to submit to authority, his increasing eccentricity, and his disdain for economic entomology in favour of taxonomy, must have coloured this decision. What followed was a period of great stress and anxiety for Girault. To compound it, his wife had died in 1931 from pulmonary illness, leaving Girault as sole support for their five children aged 18, 16, 14, 6 and 3 years (Dahms, 1978: 154–155). Girault put food on the table by working in a quarry, and on the roads, and periodically availing himself of unemployment benefits —his son Ernest described this time as his father's 'ultimate humiliation' (Dahms, 1978: 157).

Veitch assisted Girault in obtaining a grant of £75 in 1936 from the Commonwealth Science and Industry Endowment Fund to continue work on his synopsis of Australian Chalcidoidea. Girault commenced work at the Queensland Museum for this purpose in May 1936 and in June 1937, handed the Director, Heber Longman, a manuscript of 2,483 handwritten pages. His declining health and state of penury saw him admitted to the Dunwich Benevolent Asylum on Stradbroke Island in 1940 where he died in May 1941 at the age of 57 years (Dahms, 1978: 157–159).

ROBERT JOHN GRAHAM LESTER (1941–)

Robert ('Bob') Lester (Fig. 25) was born on 28 November 1941 in Walsall, England and received his schooling at St Mary's Grammar School, Walsall. Wishing to enrol in marine biology at Imperial College he was advised that the only options available were entomology and parasitology, so he became a marine parasitologist. His

FIG. 55. A.A. Girault.

focus has been on the ecology, systematics and host-parasite interaction of parasites economically important in wild fisheries and mariculture. By admission he has 'accidentally' become an expert in crustacean parasites of fishes, protozoan parasites of oysters and baculoviruses of prawns.

Finishing his BSc in 1964, he was set the task of collecting gill parasites of whiting from the North Sea for H.H. Williams of the Commonwealth Bureau of Helminthology in St Albans. Whilst at Imperial College, Lester was diving officer for their Underwater Club, and this experience as a SCUBA diver helped him obtain his later appointment as a Fisheries Officer to the Fisheries Research Station in Hong Kong. His first cruise involved diving and exploratory trawling down to Kuching, accompanying Dr A.J 'Sandy' Bruce (Lester, 1967, 1968). Once his Hong Kong contract ended, Lester enrolled, in 1968, for post-graduate studies at the University of British Columbia, gaining his Master of Science degree in 1969. He proceeded to doctoral studies at the same institution, specialising in the dynamics of *Gyrodactylus* populations in relation to sticklebacks (Lester, 1971, 1972, 1974; Lester & Adams 1974a, b), and was awarded his PhD in 1973 (Lester, 1973). He was subsequently awarded

a Medical Research Council of Canada (MRCC) scholarship, and Fitzgerald Fellowship, to carry out post-doctoral studies with Dr Reino ('Ray') Freeman at the Department of Parasitology in the School of Hygiene, University of Toronto, where he studied between 1973 and 1975. Here he investigated the possible risk of cercariae to the eyes of bathers (Lester, 1975; Lester & Freeman, 1975, 1976). Prof. Fallis had identified the mesocercaria of a species of *Alaria*, in the eye of a boy who was a patient of opthalmologist Dr Michael O'Shea (O'Shea *et al.*, 1973a, b, c). Fallis was familiar with *Alaria* mesocercaria because his erstwhile PhD student, John C. Pearson, had in the 1950s worked on the life cycles of local *Alaria* species (Pearson, 1954, 1956). Lester's work with cercariae led him to investigate fish responses to infection and the role of leucocytes in fish (Lester & Desser, 1975; Desser & Lester, 1975; Lester & Daniels, 1976; Lester & Lee, 1976; Lester, 1977; Lester & Huizinga, 1977). He subsequently won a fellowship to the Department of Pathology at the Ontario Veterinary College, University of Guelph, to investigate changes in the blood of infected salmon. Here he worked for nine months a year with Dr Joan Budd, and the other three months with Dr Margolis and Dr Evelyn at the Pacific Biological Station at Nanaimo, British Columbia (Lester & Budd, 1979).

It was Lester's association with Reino Freeman, as a post-doctoral fellow at the Unviersity of Toronto, that led him to learn of a teaching and research position at the Department of Parasitology at the University of Qucensland. Lester Cannon, a previous PhD student of Freeman's, had contacted him to enquire if he knew of a marine parasitologist who might consider coming to Queensland. According to Bob Lester, he applied for the University of Queensland position '[...] partly because it sounded a perfect blend of parasitology and fisheries and partly because of the outstanding reputation of parasitology at the University of Queensland through the scholarship of Professor [John] Sprent.' Appointed to the Department of Parasitology as Teaching and Research Fellow in 1977, Lester was appointed Lecturer in 1984 and Reader in 1989. He became Professor of Parasitology and Head of Department in 1996. In 1998 the Faculty of Science had a name-change to Faculty of Biological and Chemical Sciences (BACS). On 1st January 1999 the Department of Parasitology was merged with the Department of Microbiology, to become a single Department of Microbiology and Parasitology within the new Faculty BACS. Lester continued as Professor of Parasitology within the new department which once more transformed into the School of Molecular and Microbial Sciences and Centre for Marine Studies.

Lester's main research interests are parasites of marine animals, their ecology, effect on host populations and the application of marine parasitology to fisheries management and aquaculture. Other research interests include investigations into abalone disease carried by *Perkinsus olseni*, oyster disease such as QX disease (marteilliosis), prawn diseases and parasitic infections in sea-caged tuna. Since 1977 he has received 35 external grants for his research at the University of Queensland, totaling in excess of $2 million.

From 1978 to date, Lester has supervised to graduation, 43 Honours and 9 Masters Qualifying students, 6 Master of Science students and 16 Doctor of Philosophy students. In 2002 Lester was the inaugural Head Subject Examiner for the Australasian College of Veterinary Scientists (ACVS) for the field of Aquatic Animal Health, which led to his being invited to Membership of the ACVS. Currently he is Emeritus Professor in the BACS, where he continues to give lectures in marine parasitology, and to co-supervise Honours students. Lester has published over 125 articles in refereed journals, 15 papers in conference proceedings, 7 chapters in books, 8 reports, and has edited one book. He is also a Fellow of the Australian Institute of Biology.

MABEL JOSEPHINE MACKERRAS (1896–1971)

Mabel Josephine Bancroft (Fig. 56), was born on 7 August 1896 at Deception Bay, twenty miles north of Brisbane (Sprent, 1972b), bearing a fine scientific pedigree. Josephine's father was Thomas Lane Bancroft, M.B., ChM., who practised medicine in various parts of Queensland and New Zealand, before devoting himself to research in natural science. Her grandfather, Joseph Bancroft, was a physician from Manchester, England. He arrived in Brisbane in 1864 where he distinguished himself as a doctor, administrator and scientist until his death thirty years later. The diversity of his scientific interest was impressive. He began plant-breeding experiments on his 12½ acre property 'Kelvin Grove' on Enoggera Creek in Brisbane; he investigated the medicinal properties of native plants and used extracts of these with useful results (Mackerras & Marks, 1973); and he imported new varieties of rice from India,

sugar cane from the West Indies, wheat, barley and other cereals from the United States, and over forty varieties of clover and grasses from Europe. Becoming a successful landowner, by 1890 Joseph Bancroft owned 3,780 acres between Burpengary and Deception Bay. At the Deception Bay property he established experimental plots, orchards and farmland. Additionally, he pioneered a process of dessicating meat and vegetables to produce a heat-dried powder called 'Australian Pemmican' which was canned, but could be exposed to air for long periods without decomposition. Patented in 1867, this product was used with success with hospital patients, and by sea captains on long voyages. Also at Deception Bay, he studied the biology and culture of oysters, and the artificial production of pearls. He contributed greatly to the study of diseases in plants and was the first in the world to identify that the *Fusarium* disease of bananas was a fungus. Joseph Bancroft's contributions to public health in Queensland included the prevention of infectious disease, and improvement in the quality of medical practice. He is immortalised by the fact that the specific name of the causative organism of human filariasis, *Wucheria bancrofti*, is named in his honour. The scientific contributions of the Bancroft dynasty — Joseph, Thomas and Josephine — spanned more than a century from 1866 to 1970 (Mackerras & Marks, 1973). Their outstanding contribution was acknowledged in 1991 by naming the laboratories of the Queensland Institute of Medical Research laboratories in Brisbane, as The Bancroft Centre (QIMR Annual Report, 1990–1991).

Thomas Bancroft was born in Nottingham, England, on 2 January 1860, accompanying his parents and sister to Brisbane in 1864. As a boy at Kelvin Grove he assisted his father in pharmacological experiments with Australian flora. In 1877 he attended Edinburgh University to study medicine, graduating MB, Ch.M. in 1883 with a medal in botany. Returning to Queensland in 1884, Thomas began work in the Brisbane Hospital but was observed by his superiors to be more interested in scientific research than in medicine. Following a variety of rural appointments, plus a year in Christchurch, New Zealand, Thomas returned to Brisbane in 1889 where he joined his father and cousin in private practice. Following his father's death in 1894, he inherited the huge Deception Bay property, along with the pemmican factory and experimental farm. In 1895 he married Cecilia Mary Jones, daughter of Anglican Canon Thomas Jones, and they settled in a new farmhouse at Deception Bay, where Josephine was born one year later.

Josephine attended the Brisbane Girls Grammar School, and in 1915 commenced a science degree at the University of Queensland, having gained an open scholarship. Graduating Bachelor of Science (Honours) in 1918, she was awarded a Walter and Eliza Hall Fellowship in Economic Biology, and carried out research with the Head (later Professor) of the Biology Department, Dr T. Harvey Johnston (Mackerras & Marks, 1973). Johnston was a biologist with wide-ranging interests, and had already started to publish a series of important papers on parasites of Australian animals (Sprent, 1972a). Josephine's first sixteen publications were in collaboration with Johnston, including two comprehensive papers on tick-resistance in cattle (Johnston & Bancroft, 1918, 1919). In 1920, Josephine enrolled in 2nd-year medical studies at the University of Sydney, where she met a returned serviceman from World War I, Ian Murray Mackerras. Graduating MB (Honours) in March 1924, she and Ian Mackerras were married at her parents' home at Eidsvold Queensland, the following month, having to sell one of their microscopes to finance

FIG. 56. Dr M.J. Mackerras: Oil on canvas by Nora Heysen Australian War Memorial 24395. ca 1945 (Reproduced with permission of War Memorial, 8 July 1999).

their rail travel from Sydney. Returning to Sydney, Josephine worked as Resident Medical Officer at the Royal Prince Alfred Hospital and Ian took up a research scholarship at the University of Sydney (Mackerras & Marks, 1973). Their son David was born in 1926. In 1929 the Mackerras family moved to Canberra, Ian having been appointed to the CSIR's (later CSIRO) newly formed Division of Economic Entomology (CSIRO Archives, 26 October 1929). In October 1930, Josephine joined CSIR as Junior Entomologist (CSIRO Archives 7 October 1930). Her main contribution during this phase of her career was her research on the sheep blowfly *Lucilia cuprina,*. She maintained breeding stocks of *Lucilia* and published her first single author paper on their biology (Mackerras, 1933). She also carried out important bacteriological work in connection with blowfly strike (CSIRO Archives, 5 August 1931). In collaboration with other workers, she investigated the pathogenesis of blowfly strike and the physiology of blowflies, and fly repellents and dressings for flystruck sheep (Mackerras & Freney, 1933; Freney *et al.*, 1935, 1936). Josephine Mackerras became leader of the CSIR's blowfly control research team in Canberra (CSIRO Archives, 4 February 1936), and in 1936 took nine months' leave without pay in order to investigate blowfly research in Britain, and the incidence of fleece rot in relation to body strike in sheep (CSIRO Archives, 26 February 1936).

With the advent of World War II, Josephine resigned from CSIR in June 1940 (CSIRO Archives, 23 May 1940), and whilst awaiting call-up to the Australian Imperial Forces (AIF), she refreshed her medical knowledge by carrying out part-time work at the Rachel Forster and Renwick Hospitals in Sydney (CSIRO Archives, 23 May 1940). She was appointed pathologist with the rank of Captain in the AIF on 7 February 1942. In 1943, the Land Headquarters Medical Unit was established at Cairns to conduct research into malaria control with suppressive drugs. This Unit was under the command of Brigadier Hamilton Fairley. Josephine was promoted to Major and transferred to Cairns where she was in charge of breeding and maintaining colonies of mosquitoes infected with *Plasmodium* spp. These mosquitoes were used to infect volunteer Army personnel on whom suppressive drugs were trialed. The Unit was disbanded in March 1946. The wealth of information accrued by the Cairns Malaria Research Unit on malaria parasites and their anopheline vectors, was published through 1947 and 1948 in collaboration with F.H.S. Roberts (Mackerras & Roberts, 1947), Q.N. Ercole (Mackerras & Ercole, 1947; 1948a, b, c; 1949a, b), and T.H. Lemerle (Mackerras & Lemerle, 1949). More recently, an historical account of the Cairns Malaria Unit has been compiled by Lt. Col. A.W. Sweeney (see Sweeney, 1996).

Ian and Josephine Mackerras returned to CSIR in Canberra in March 1946, following their discharge from the Army, but one month later were appointed to the CSIRO laboratory in Yeerongpilly, Queensland. Here Josephine began research on blackflies (Simulidae) (Mackerras & Mackerras, 1948a, 1949a). She was appointed Senior Parasitologist at the QIMR on 1 September 1947 (Mackerras & Marks, 1973) following her husband Ian's appointment as Director of QIMR in March that year. Here she played a major role in the epidemiology of an epidemic of *Salmonella* gastro-enteritis in infants and children. Josephine discovered that cockroaches served as reservoirs of infection, and in collaboration with her husband, she published five papers on the topic (Mackerras & Mackerras, 1948b, 1949b, c, d, e). During their time at QIMR from 1947–1961, Ian and Josephine Mackerras published 18 of their 24 joint papers (Spratt, 1980), with four concerning parasitology. During this same period however, Josephine herself published 25 parasitological papers (Mackerras & Marks, 1973), including her classic studies on the haematozoa of Australian vertebrates (Mackerras, 1959, 1961). She also elucidated four important life cycles, with that of the rat lungworm, *Angiostrongylus cantonensis* generating considerable international interest. In this she was greatly assisted by Dr Dorothea Sandars (Mackerras & Sandars, 1955). It eventuated that the lungworm species they had studied was not in fact *A. cantonensis* but a new species identified by Mahmoud Bhulbaiya, a PhD candidate of John sprent's, which he named *Angiostrongylus mackerrasae* in Josephine's honour (Sprent, 1972b). Mackerras & Sandars showed that the larvae of the rat lung-worm require a prolonged period of development in the rat's brain before migration via the heart to the lungs. Though causing little reaction in rats, their experiments revealed that infections in mice caused a marked inflammatory reaction in the brain and meninges. Josephine postulated that obscure cerebral infections and lesions in humans may be attributable to accidental infection with this parasite. This was later proven correct by French and American scientists working in the Pacific. *A. cantonensis* was found to cause eosinophilic meningitis in humans, with

infection the result of inadvertent ingestion of the larvae in raw prawns, or in slugs on lettuce (Mackerras & Marks, 1973).

Retiring from QIMR in 1961, Josephine and her husband Ian returned to Canberra, where she assisted him in producing the monumental work, *The Insects of Australia*, to which she contributed the chapter on Blattodea (CSIRO, 1973).

Josephine Mackerras was awarded Doctor of Science *honoris causa* by the University of Queensland in 1967 — an honour she prized highly. She died in Canberra in 1971 from localised cerebrovascular disease (Mackerras & Marks, 1973). Her outstanding research was recorded in 86 papers published between 1918 and 1970, 13 of these being devoted to the taxonomy of Australian cockroaches.

Dr Mabel Josephine Mackerras, MD, DSc, MRCPA, has been described by Prof. John Sprent (Sprent, 1972b) as '[...] a penetrating observer and a scrupulously honest investigator [...] no ordinary person, but possessed [of] a rare feature [...] a humility and natural kindness which transcends all boundaries, of knowledge, of age, of language [...]'.

JOHN CAWARDINE PEARSON (1927–) (AUTOBIOGRAPHICAL NOTE)

On Christmas Eve of my sixth year I woke in the night to see my older brother — he was seven — putting a box into my stocking hanging at the foot of the bed. My feelings on seeing this were mixed. I knew that in the box was the microscope I longed for, but I was disappointed to learn that there was no Santa Claus. When I was nine, my father gave me a much better microscope, a French one, brass, in a wooden box. I soon found the greatest pleasure in watching aquatic animalcules, such as rotifers and protozoans, aided by two books my father gave me: *The Microscope Made Easy* which had a chapter on Pond Life [28], and *A Guide to the Study of Fresh-Water Biology*, the latter a collection of illustrated keys. I still have both books.

A few years later my older brother and I joined the insect group of the Junior Field Naturalists at the Royal Ontario Museum of Zoology. He was keen on butterflies and moths, and I was keen on aquatic insects. Having found some tiny snail shells in the garden and wondering whether they could be relicts from an earlier post-glacial lake, I took them to the curator of molluscs at the Museum, Dr Jack Oughton, who told me they were shells of contemporary land snails. My interest in snails grew and I paid several visits to Dr Oughton, who asked me if I was interested in a job at the Museum — Saturday mornings during term and longer in the summer holiday. And so began for me a happy association with the first of the three men who strongly influenced my career. One summer I went as his assistant to Algonquin Park, my first introduction to the Canadian bush. I had never seen such forest and so when asked for my first impression I answered: 'All those trees !' which raised a laugh, although it was an honest answer. Looking out over rolling country with a solid canopy of trees was impressive. Dr Oughton was taking bottom samples in Lake Opeongo and had offered to collect small spiders for the Museum's arachnologist, Tokasuma Kurata. This delightful Japanese man was [subjected to a display of xenophobia by being] stoned in San Francisco as he got off the boat that had brought him to the 'Promised Land'. I was given the task of collecting tiny spiders from low vegetation. This involved beating bushes with a stick over a square of white cloth and sucking up the dislodged spiders and pickling them in alcohol. The 'sucker-upper' (aspirator) is illustrated above.

Of course, once in the bottle the spiders dashed about attaching their safety lines as they went, and the bottle was soon a tangle of threads, making it hard to get the spiders out and into a vial of alcohol. Thinking to avoid this, I put alcohol in the bottom of the bottle to kill the spiders before they had time to attach their threads. Well, it worked, but not for long because I was soon too dizzy to collect them. So, back to the dry bottle and the tangle of threads. At the Museum I handled only empty [snail] shells until the Saturday morning I came in to find an aquarium of planorbid snails (*Helisoma*) in a cloud of tiny, furiously swimming animalcules of a type I had never seen. It was, to my astonishment and delight, a cloud of cercariae — echinostome, as I learned later — my introduction to the endlessly fascinating life-cycles of flukes. By degrees my interest in molluscs was matched by my growing interest in flukes and other helminths. So, when on putting in for a summer job at the end of my first year at university, I was asked by Professor Coventry (who taught first-year zoology and ran an employment bureau for Zoology staff wanting assistants for summer field-work) what my interest was, I said 'Parasitology' and had the great good fortune to

be taken on by Prof. Murray Fallis as an assistant in his research on avian haematozoa in Algonquin Park for two summers, one on Lake Opeongo and one on Lake Sasajewan, and a third summer worked on my own on swimmers' itch, a project that continued after graduating and became my MA thesis.

In the long vacation between finishing an MA and enrolling for a PhD, Roy Anderson and I were taken on at the Ontario Research Foundation (ORF) to identify the helminths collected by John Sprent or his assistant, from carcasses of native mammals supplied by the ever-helpful Wildlife branch of the Ontario Department of Lands and Forests. Roy tackled the nematodes, later becoming an outstanding nematodologist. I happily took on the flukes and not so eagerly, the tapeworms. We shared a room at the Foundation that summer and for the following four years as graduate students. Among the flukes were diplostomes of the genera *Diplostomum, Alaria* and *Fibricola* from the canids fox, brush wolf and timber wolf; the felids lynx and bobcat; the mustelids mink, marten, fisher and skunk; and from the otter. The life-cycle of *Alaria* looked intriguing, and so I proposed to Murray Fallis a PhD project on the life-cycles of the two abundant species of *Alaria* I had identified. He agreed with enthusiasm. It was months before I finally saw cercariae from an experimentally infected lab-reared snail. My spirits rose and work really got underway.

While busy with *Alaria,* I was offered a dying snowy owl by Dr Dave Fowle, Wildlife, Lands and Forests. In it I found a species of *Strigea* and one of *Diplostomum.* The flukes were alive and numerous, so I fixed some and dissected some for their eggs, which I put in the fridge against the day when I might have time to use them. Almost a year later I was so sick of writing up that I got out the eggs and warmed some up and found they could still develop and hatch. So, to ease the tedium of the thesis, I put miracidia with various lab-reared snails and got cercariae of both, and for the *Diplostomum* a metacercaria, for the *Strigea* a mesocercaria which was fun because it was the same stage as seen in *Alaria* yet the two genera were widely separated taxonomically.

Arriving in Australia in late January 1956, I began by autopsying any and all vertebrates that came to hand at the old Vet School at Yeerongpilly. In June I went to Heron Island to look at parasites in fish trapped by David Woodland, a student of Prof. Stephenson in Zoology, University of Queensland. Getting there was an interesting experience. I accompanied three members of the Great Barrier Reef Research Committee, Dr Ian Mackerras (Queensland Institute of Medical Research), Dr Bob Endean (University of Queensland) and Noel Haysom (Queensland Fisheries). The train was smaller than a Canadian one, and the bunk bed was cross-wise rather than lengthwise, so had a very different motion. And instead of a club car on the train, there was scalding tea in a thick cup at a station when the train stopped briefly. Because of a feud between the research station caretaker and the owner of the resort, visitors to the station couldn't use the resort's boat, but instead crossed in the once-a-fortnight mail boat, which was pleasant if slow. At the edge of the reef I was off-loaded (with John Sprent's camera, my luggage and dissecting microscope) into a small dinghy to be rowed ashore. There wasn't much water over the reef and so the swell on reaching the reef turned into waves, one of which dumped the inexpertly rowed boat and left me standing in my town shoes, holding the microscope box, and with Sprent's camera around my neck and my suitcase floating free. It was a slow trudge to the beach. My clothes — on me and in my case — ended up full of salt, many of the cigarettes I had brought were ruined and my shoes never recovered. My temper abated once I had met David and saw what a fascinating lot of fish he was trapping, and the delights of pottering on the reef at low tide and round the island at high tide. Together with many flukes and a few nematodes and acanthocephelans, I was introduced to tetraphyllid and trypanorhynch tapeworms and to the astonishing amphiliniids.

The station was a single building with a large central lab-cum-kitchen and four small rooms off it, without electricity. David did the cooking on a kerosene stove. Our most memorable meals were a very large spiny lobster (a bit tough) and on the eve of my departure, a twelve-egg omelette. Neither meal could we finish.

To add variety to our catch, we had a go at fishing for shark. Late one afternoon we anchored the dinghy in the channel and between Heron Island and Witsari Reef, dropped in a very large, baited hook on a wire trace and a length of stout rope tied to a ring on the prow. We sat back line fishing for the pot. About dusk, suddenly the prow dipped alarmingly and then swung smartly to one side; then the rope snapped and by degrees our hearts resumed their proper place. We didn't try it again.

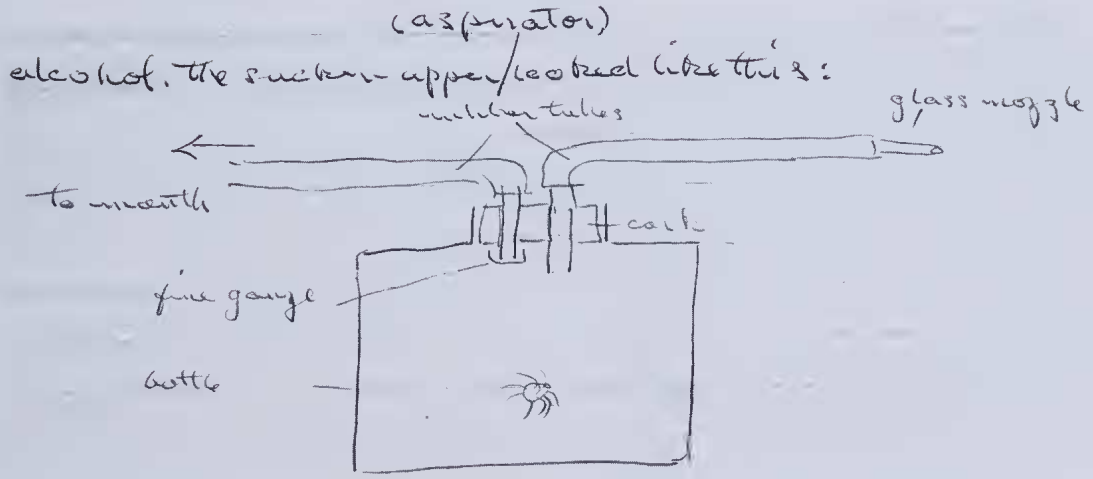

FIG. 57. 'sucker-upper' (aspirator).

David emptied the trap at low tide and hauled the catch in gunny sacks up the short but sharp rise from beach to island. One day while hauling, he dropped the sack and sank onto the sand, crying out 'Oh, no!' When I reached him he was clutching his calf just above an embedded sting from a ray. The sting must have been projecting a bit through the sack, and was driven into his leg when the heavy sack slipped against it. What to do? David asked me to get our only source of information on stingrays, which was a South African book on the fishes of the Indian Ocean, used by David to identify his catch as best he could. Having looked up stingrays and deciding that David's sting could be dangerous, we agreed that it had to come out. There was no-one on the island to help, so it fell to me to get it out. A cut either side with a new razor blade, a splash of antiseptic, then taking a firm hold on the barbed sting while David clutched his leg and looked away, I yanked. David groaned, and out it came. I found gauze and antibiotic paste, covered the wound, and David went to bed in considerable pain. Fortunately a G.P. turned up a few days later on a private boat and agreed to look at David's leg. His only criticism was that a powder-based antibiotic, which was in our first-aid kit, would have encouraged faster healing than the wet paste I had used. While David mended, I emptied the trap. When I got back to Brisbane, leaving David on the island, I was hailed as a hero for dashing into the pounding surf to rescue a fair damsel attacked by a stingray, and carrying her back to shore. David wasn't impressed by this tale on returning to Brisbane.

My greatest catch while minding the trap was a large 4ft 3inch barracuda (Fig. 58) which I was lucky to dispatch with a single thrust of a harpoon that hit the fish just behind the head, whereupon it thrashed briefly and turned belly up. In it I found didymozoid flukes, nematodes and trypanorhynch cysts.

I had gone to Heron Island for two weeks, the interval between visits of the mail boat, but said boat was laid up in Gladstone harbour, damaged by a storm. It took another two weeks to find a lift to Gladstone on a commercial fishing boat that, between fishing and getting stuck for several hours on a sand bank at the mouth of Gladstone harbour, took 22 hours to land me in Gladstone, too late for the train to Brisbane and not a bed in any pub. I spent the night in a soggy bunk in the damaged mail boat and caught the train back next day.

By late 1956 I had found a new diplostome in the bush rat, *Rattus fuscipes*, at Mt Glorious and had decided to attempt to work out its life-cycle. So, needing laboratory-reared snails and tadpoles, I searched the streams at Mt Glorious. The commonest snail was the tiny *Posticobia brazierii* , a prosobranch, not the pulmonate I had expected for a *Diplostomum,* and at first difficult to raise and, as it turned out, impossible to infect. Eventually I found a tiny limpet, *Pettancylus assimilis*, a pulmonate, not too easy to raise in numbers but a proper host for my diplostome and an ideal size and shape for observing the escape of cercariae. The commonest frogs were a small, dark one I thought might be a *Crinia* and a small tree frog, then in *Hyla* now in *Litoria*. Using the

keys available, Parker on leptodactylids, now myobatrachids; and Copland on *Hyla*, I couldn't identify the first to genus, nor the second to species. On the advice of Dr John Calaby, CSIRO Wildlife, I sent the dark frog to Dr Bert Main, University of Western Australia, who said flatly that it was a tree frog, a *Hyla*, which I knew it couldn't be as I had found by dissection that the toes, although expanded terminally, did not have the hylid intercalary cartilage between the last two bones but had instead, a T-shaped terminal phalanx. I had also sent specimens of this frog to Parker at the British Museum of Natural History in London [now The Natural History Museum], who pointed out that it was close to *Crinia acutirostris* from the Atherton Tableland. Later, Ian Straughan showed this to be a second species of *Taudactylus*. Ian began a PhD study of Queensland frogs under Dr Maurice Bleakley in Zoology, University of Queensland and (unofficially?) under Dr Tony Lee, a young Lecturer. Ian was interested in my description of the very common *Crinia* at Mt Glorious, but was frustrated at not finding any himself on several visits. I was surprised and he was puzzled. Then over the same weekend we separately twigged to it. I collected by day; he collected by night. Hence, its common name of day frog and specific name *diurnus*. As I couldn't key out the *Hyla*, I sent it to Copland, who decided it was new and named it *pearsoni*, much to my children's pleasure. It was, and still is in most accounts, known as Pearson's tree frog — 'our frog' to the children — but is now called the cascade tree frog at the Queensland Museum.

While dissecting frogs for diplostome metacercariae, I found two interesting extras in

L pearsoni. The first was a large subcutaneous cyst containing the metacercaria of a new genus of heterophyid. The second was a polystomatid monogenean, genus *Parapolystoma*, full of large eggs which it readily laid in water where they developed and hatched out to give a large handsome oncomiracidium that swam majestically, like a Spanish galleon, making miracidia look like scurrying mice. From lab-reared and wild-caught tadpoles I learned that there was no gill adult as in *Polystoma*, but instead an immature bladder adult with partially developed hamuli and underdeveloped reproductive system, that is, a more primitive cycle than the classical cycle of *Polystoma*.

In 1961, when the department was divided — Allan Waddell and I at St Lucia and everyone else at Yeerongpilly — Ann Pritchard, then as now a member of the department, sent across some spiny nematodes in saline from the lungs of a blue-tongued skink. The worm, *Pneumonema*, was said to be a spiruroid, but together with adult worms there were tiny larvae that showed a rhabditiform pharynx. And the adult, on examination, did not have a two-part spiruroid pharynx. Indeed, the worm appeared to be a rhabdiasoid. Rob Ballantyne, then my assistant, took over and studied the life-cycle for his Honours thesis and together with four other related genera (including one new but unpublished) for his PhD thesis.

Having finished *Diplostomum*, I shifted to heterophyids, which had been accumulating from a variety of birds, such as skinned, frozen carcasses of terns and waders collected by Don Vernon at the Queensland Museum; and live egret nestlings fallen from nests in the colony of intermediate egrets in the old Botanic Gardens, courtesy of the curator of the Gardens. This was a great source of living heterophyids and other flukes until the egret rookery was routed by an avalanche of flying foxes displaced from Fisherman Island by clearing of the mangroves for the container port, and which having chased away the egrets, and I think, night herons, moved on to their present camp on an island off the Indooroopilly Golf Club. Other birds were pelican, cormorant, and Brahminy kite; of mammals, the water rat was far and away the best source of both heterophyids and microphallids. This in the days when we could live-trap them at the Vet School farm.

In 1962, on one of their northern trips, Frank Boyes, aquarist, and Keith Williams, all-round naturalist, live-trapped water rats at Mossman, north Queensland and shipped them down by train to me. On one occasion, I picked up from Roma Street Station, a crated water rat and set off back along Coronation Drive to take it to the Vet School at St Lucia. As I was approaching the Regatta Hotel, I felt a curious tickling under my left ear and on turning to see what it was, found the water rat sitting on the top of my seat. What to do? It was dark, the road fairly busy, and I had no way of trying to catch it, so I blew in its face, causing it to jump into the back, and I drove on to the Vet School. Here I got out of the car carefully, found a live trap and a torch, got into the car again and slowly hunted for the water rat, being lucky enough to chivvy him into the trap. At autopsy later, I found *Opisthorchis* in its bile ducts.

Initially, my interest in heterophyids was all-inclusive: morphology, taxonomy and life-cycles. But as almost all attempts to infect fish with cercariae and so obtain an identifiable metacercaria failed, and as lecturing and preparing and giving laboratory classes increased, I found it easier to pick up and drop taxonomic work than the more intensive and time-consuming life-cycle studies. And taxonomy being what it is, what began as a study of three genera, [*Haplorchis, Procerovum* and *Stellantchasmus*] grew and grew until by the time I retired I had learned something at first hand of most genera of heterophyids, so was ready to accept the challenge of preparing an illustrated key to genera for the forthcoming book, *Keys to the Trematoda,* to be published in three volumes by CAB (Commonwealth Agricultural Bureau) International.

ADDENDUM. John Pearson had a distinguished career. He was awarded a DSc from the University of Queensland in 1972, and given a personal Chair in Helminthology in 1986. Among his distinguished students was Peter Young, later to become Chief of Division CSIRO, Fisheries; Howard Choat, now Professor of Marine Biology at James Cook University of North Queensland; Rob Ballantyne who became Head of Biological Sciences at Charles Sturt University, Wagga Wagga; and Tom Cribb, now Associate Professor in the Centre for Marine Sciences, University of Queensland. A trip to the Great Barrier Reef and Heron Is., was often a spur to careers (Fig. 59), as was the encouraged visit of an eminent scientist (Fig. 60).

FIG. 58. Prof. J.C. Pearson: displaying his catch of barracuda, Heron Island, Queensland, 1957; (Courtesy J.C. Pearson).

MICHAEL ALAN PEIRCE (1942–)

Michael Peirce (Fig. 61) was born in London in March 1942. On completing his schooling in 1959 he joined the Department of Entomology in the London School of Hygiene and Tropical Medicine (LSHTM), where he learned to culture insects of medical importance, and use them to test insecticides. He left the LSHTM in 1961 to join the Ministry of Agriculture, Fisheries and Food (MAFF) at their Central Veterinary Laboratory's Department of Parasitology in Addlestone, England. Here he gained experience in research into parasitic protozoa, the first blood smears he examined being from sparrows, one of which contained *Haemoproteus* (Peirce, 1967). During the 1960s, MAFF received all dead birds arriving at the quarantine station at London's Heathrow Airport, enabling Peirce to study the blood parasites of birds, particularly from Asia (Peirce, 1969). He also carried out histopathology and helminthology studies (Kendall, Hebert & Peirce, 1969; Kendall & Peirce, 1969; Kendall, Thurley & Peirce, 1969).

Between 1968 and 1970 Peirce was seconded to the East African Veterinary Research Organisation, being based at Muguga Veterinary Research Station outside Nairobi (Fig. 61B). Here his protozoology work included investigating tick-borne disease. Additionally, this appointment allowed him to expand his studies on the blood parasites of birds, such studies being enhanced by his association in Kenya with the Backhurst's (Peirce & Backhurst, 1970; Peirce, Backhurst & Backhurst, 1977). Graeme Backhurst was Head of the East African Bird Ringing Association, and he and his wife were studying migration of palearctic birds. Amongst the tick-transmitted diseases Peirce studied were pathogens transmitted by argasid ticks of the genus *Ornithodoros* (Plowright, Parker & Peirce, 1969a, b; Plowright *et al.*, 1970; Plowright, Perry & Peirce, 1970).

Much of Peirce's work in Kenya centred on tick-borne diseases as reflected by his many

FIG. 59. J.C. Pearson (far right) and two research students at Heron Island, Queensland, 1963. Peter Young, later Chief of CSIRO's Division of Fisheries in Hobart, Tasmania and Rob Ballantyne, later Head, Biological Sciences, Charles Sturt University, Wagga Wagga, New South Wales; between them Howard Choat (Zoology Dept.), later Professor of Marine Biology at James Cook University of North Queensland. (Courtesy Professor J.C. Pearson).

collaborative publications between 1970 and 1975 and this included studies of ectoparasites of East African vertebrates (Peirce, 1975a) (Fig. 59A). From the early 1970s however, he began concentrating on the taxonomy of avian haematozoa (Peirce, 1974, 1975b, 1977; Peirce & Cooper, 1977a, b). He returned to MAFF in 1970 where he continued with research into ticks and tick-borne disease and developed immunological tests for piroplasmosis (Peirce *et al.*, 1972; Peirce, 1973; Peirce & Neal, 1974; Peirce & Gallagher, 1974). He was however, to return to investigations into avian haematozoa (Cheke *et al.*, 1976; Peirce & Cheke, 1977; Peirce & Bevan, 1977; Peirce & Cooper, 1977c; Peirce, 1979; Peirce & Prince, 1980).

Whilst attending a conference on blood parasites of birds in 1971, he met Prof. Gordon Bennett (Fig. 45B) who, since 1969, had been in charge of the International Repository of Avian Blood Parasites in the WHO International Reference Centre for Avian Malaria Parasites at Memorial University, St Johns, Newfoundland. Peirce and Bennett became friends and collaborators on research into avian blood parasites, and in 1978 Bennett invited Peirce to become a corresponding associate of the re-named International Reference Centre for Avian Haematozoa (IRCAH). In 1973, Peirce had been invited by Prof. Marshall Laird of the Department of Biology at Memorial University, to join Bennett in working on the 'Centre' as it became known. Laird had been instrumental in WHO's designating Memorial University as the repository for the IRCAH. Peirce declined Laird's invitation, since he hoped at a later date to return to Africa. Before doing so however, he met Chris Mead who worked for the British Trust for Ornithology (BTO), the principal academic bird society in Britain. This provided Peirce with links to other ornithologists and through this association, Peirce was invited to join a one-month British Ornithologists' Union (BOU) expedition to Mauritius in 1974 where he studied the prevalence of haematozoa in both endemic and introduced bird species. This association with Mauritius has continued until the present time and Peirce has been actively involved in the Pink Pigeon Project currently run under the auspices of the Mauritian Wildlife Foundation. The pink pigeon was, in the 1970s, a very rare species with numbers down to between 20–30 birds. A captive breeding program has been successful in boosting the numbers of birds released back into the wild

FIG. 60. Department of Parasitology staff and post-graduate students at the University of Queensland, 1963. Rob Ballantyne, Don Chatagovani, Duncan Hoyte, Alan Waddell, Peter Young, Prof Harold Manter, John Pearson, Thais Brooks, Pat , Tom Stegingar, Tania Verstak. (Courtesy Professor J.C. Pearson).

but population numbers have been prevented from increasing adequately due to mortalities particularly in squabs; one of the primary factors being the pathogenicity of infection with *Leucocytozoon marchouxi* (see Peirce, Greenwood & Swinnerton, 1997). Since meeting Chris Mead, Peirce and he have carried out collaborative studies on the haematozoa of British birds (Peirce & Mead, 1976, 1977, 1978a, b). These studies have been subsequently expanded by Peirce (1980, 1981a), with others (Peirce & Marquiss, 1983) and again with Mead (Peirce & Mead, 1984).

In 1974 Peirce was invited by Don Forrester (Fig. 62) to study for a PhD at Gainsville, Florida, working on turkey haematozoa which was proving to be a problem. However there were difficulties in Peirce's moving to the United States at that time, so he had to decline. Another opportunity was to present itself for him to do a higher degree, when in 1977 David Molyneux[29] returned to Britain from West Africa to take a Chair at the University of Salford in Manchester. Peirce and Molyneux had long been associated through research into avian haematozoa when Molyneux, a protozoologist, had been working in West Africa with the WHO. He invited Peirce to undertake doctoral studies at Salford, but Peirce was unable to study fulltime since their application for funding was unsuccessful. Peirce subsequently undertook part-time studies and this situation continued when in 1979 he joined the United Nations' Food and Agricultural Organisation (FAO) in Zambia. Here he worked for two-and-a-half years at the Central Veterinary Laboratory in Balmoral, south of Lusaka, Zambia. He was awarded his PhD in 1983 after five years' part-time study (Peirce, 1983).

Between 1979 and 1982 Peirce investigated ticks and tick-borne protozoan diseases of domestic stock (Musisi & Peirce, 1981) and wildlife, and protozoal diseases of mammals and reptiles (Patterson & Peirce, 1982; Peirce, 1984c; Norton & Peirce 1985). More particularly however, he studied the haematozoa of Zambian birds. (Peirce, 1981d, 1984a, b, d, e, h, i, j, k, n, o, p). Between1980 and 1982 Peirce was honorary Wildlife Ranger for the Zambia National Parks and Wildlife Service, involved in anti-poaching activities (Fig. 61).

During his period in Zambia, as a corresponding associate of the IRCAH Peirce collaborated with Bennett in sorting out some anomalies in taxonomy and nomenclature in the Russian literature (Peirce & Bennett, 1979), as well as reviewing the avian family Zosteropidae (Bennett & Peirce, 1981). Additionally, Peirce compiled a host-parasite checklist of haemoprotozoa of birds in Western Europe (Peirce, 1981b).

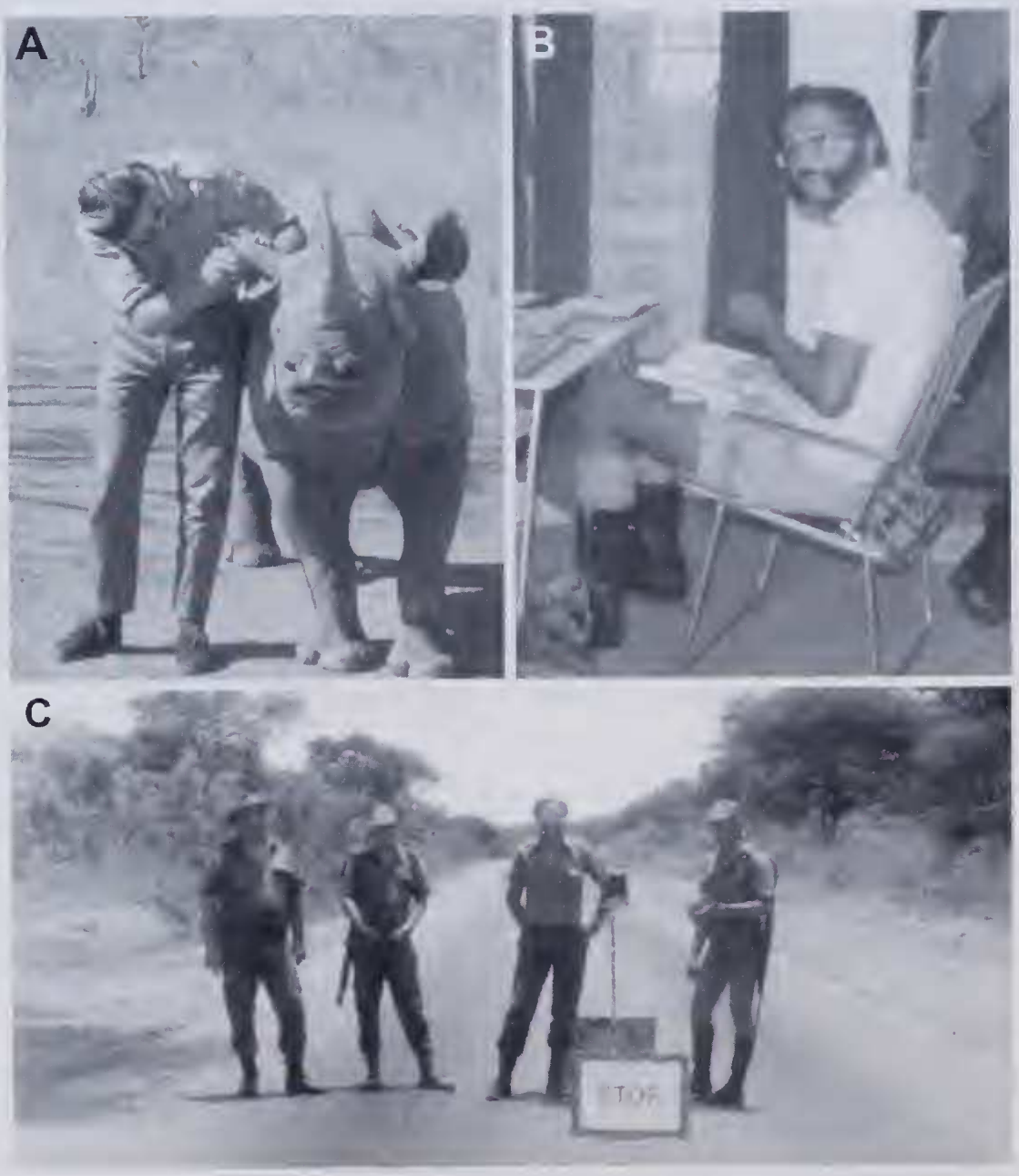

FIG.61. Dr. Michael Peirce: A, Collecting ticks from rhino ear - Kenya, 1969; B, dissecting a bird at Mugugu Agricultural Station in Nairobi, Kenya; C, on patrol with the National Parks and Wildlife Branch, Zambia.

In 1982 Peirce returned to MAFF, joining their Medicines Unit (later the Veterinary Medicines Directorate) Pharmaceuticals Team. Here he was assessor of the efficacy and safety of new veterinary products, specifically the ectoparasiticidal and anthelminthic formulations. On his return to Britain Peirce's collaboration with Bennett increased dramatically, with 28 papers being published between 1985 and 1994. He also published a number of single author papers (Peirce, 1987, 1989a, b, 1993), and with others (Peirce & Brooke, 1993). When Peirce voluntarily retired

from MAFF in 1994 to concentrate on being an independent consultant, Peirce & Bennett (1996) produced a revised key to the avian sub-genera of *Plasmodium* which was published subsequent to Bennett's premature death in December 1995. On Peirce's return to Britain from Zambia, he had been approached, in 1985, by Tony Harris at the Transvaal Museum, South Africa in relation to parasites of shrikes. Harris offered to send material from these and other birds, but since Peirce could not cope with the extra workload he put Harris in touch with Gordon Bennett at Memorial University, Newfoundland. Harris also put Bennett in touch with Roy Earle who was at Bloemfontein, and thus began the profitable collaboration with South Africa (Bennett, Peirce & Earle, 1990; Bennett, Earle *et al.*, 1993, Bennett, Earle & Peirce, 1993a, b, c; Bennett, Peirce & Earle, 1994). Other haematozoa studies were published between 1996 and 2000 (Samour & Peirce, 1996; Peirce & Bengis, 1998; Peirce, 1999, 2000a). With Prof. Valkiunus of Vilnius, Lithuania, he conducted a study of *Plasmodium corredetti* (Valkiunas & Peirce, 2000). He has carried out a review of avian piroplasms of the genus *Babesia* (Peirce, 2000b), and has investigated the proposed adoption of Berestneff, 1904, as the author of *Leucocytozoon* (Protista, Haemosporida) (Peirce, 2000c, d).

Throughout his productive career, Peirce has established a number of consultancies with various organisations worldwide but he considers the most rewarding of them to have been the pink pigeon study with the Mauritian Wildlife Foundation. He has been fortunate in enlisting the cooperation of numerous ornithologists and veterinarians with an interest in avian haematozoa. He has also had the privilege of meeting such notable parasitologists as Baker, Bennett, Forrester, Garnham, Hermann, Hoare, Lainson, Levine, Molyneux, Shortt, Telford and Young. He considers himself particularly privileged to have had such a close association with Gordon Bennett and feels that their collaboration over a number of years, together with their many taxonomic reviews, has laid the foundation for a clearer picture of the current status of avian haematozoan taxonomy.

In recognition of his contribution to research into parasitic diseases of wildlife, Peirce has had four organisms given the specific name *peircei* in his honour, viz. *Haemoproteus peircei* Forrester, Greiner, Bennett & Kigaye, 1977; *Pleuropsoloides peircei* Goodman, 1990; *Babesia peircei* Earle, Huchzermayer, Bennett & Brossy, 1993; *Leucocytozoon peircei* Bennett, Earle & Squires-Parsons, 1995.

FIG 62. Mike Peirce in Gainesville, Fla.1995 (L. to R. Dr. Martin Young, Dr. M. Pierce and Dr. Don Forrester);) (All courtesy Dr. M. Peirce).

In 1977 he was elected a Scientific Fellow of the Zoological Society of London, and in 1984 was created a Fellow of the Institute of Biology. Appointed as Honorary Consultant to the Queensland Museum in 1995 in connection with the Museum's acquisition of IRCAH, Peirce has visited Brisbane on three occasions to assist with research into avian haematozoa.

FREDERICK HUGH SHERSTON ROBERTS (1901–1972)

Frederick Hugh Sherston ('Ozzie') Roberts (Fig. 11) was born in Rockhampton, Queensland, on 16 January 1901 (Archives, CSIRO, 6 January 1948). He attended Townsville Grammar School, and in 1923 was awarded a BSc (Biology Honours) from The University of Queensland (Archives, University of Queensland, F.H.S. Roberts). Between November 1922 and April 1923, Roberts worked as a microscopist with the Australian Hookworm Campaign, and from April 1923 to January 1930, he was a research entomologist with the Commonwealth Prickly Pear Board (Archives, CSIRO, 10 January 1947). In June 1925 was awarded his MSc (Archives, University of Queensland, 1926).

Whilst working at the Commonwealth Prickly Pear Board field station at Gogango, Roberts became increasingly interested in ecto- and endo-parasites of livestock which resulted in his being recruited, in January 1930, by the

Queensland Department of Agriculture and Stock for appointment to their Animal Health Station at Yeerongpilly, as their first veterinary entomologist (Skerman, 1998). This appointment was emended in 1936 to entomologist and parasitologist. In August 1940, following an eight-month tour to study methods of parasitic disease control used in other countries, his title was altered to parasitologist.

In 1935, Roberts was the first person to be awarded a Doctor of Science degree by The University of Queensland, with his thesis on *Ascaris lumbricoides* (Roberts, 1935).

Roberts joined the Australian Army during World War II, being appointed a lieutenant in the Militia on 19 December 1941. He transferred to the Australian Imperial Force on 11 August 1942 and served with various medical units in Australia and New Guinea before being posted in May 1943 to the 2nd Mobile Entomology Unit with which he studied the behaviour of *Anopheles* mosquitoes. Promoted to the rank of Major in October 1943 at the Land Headquarters' Malaria Research Unit in Cairns, he worked closely with Major Josephine Mackerras on the biology and vector capability of Australasian anophelines (Mackerras & Roberts, 1947).

Between 1939 and 1941, Roberts also lectured part-time in parasitology to veterinary science students at The University of Queensland (Archives, CSIRO, 10 January 1947).

Following discharge from Army service on 22 March 1945, Roberts returned briefly to the Queensland Department of Agriculture and Stock as Acting Director of the Research Division of Animal Industry, but with no confirmation of this appointment, he accepted, in March 1947, the offer to join CSIR at Yeerongpilly as Officer-in-Charge of their newly created Veterinary Parasitology Laboratory (Archives, CSIRO, 25 January 1947) — a position from which he retired in 1965. Under his direction, the Veterinary Parasitology Laboratory gained international recognition for its studies on parasitic diseases of cattle.

With its increased staff and wide coverage of veterinary parasitology there was a need for larger facilities, so Roberts negotiated for the construction of a set of modern laboratories and animal-holding facilities at Long Pocket, Indooroopilly and was closely involved in their planning. In September 1968, the CSIRO Long Pocket Laboratories were occupied by groups from the Divisions of Animal Health, Entomology, Plant Industry, Land Use Research, and Mathematics and Statistics (CSIRO, 1978).

Roberts' 133 papers covered topics in pure entomology, parasitic worms and ticks. Additionally, he published two books (Roberts 1952, 1970) which became standard reference texts for students and scientists. He is recognised as one of Australia's leading parasitologists. Invariably kind, supportive and encouraging to younger scientists in his division, Roberts was a man of integrity who was gifted with a good sense of humor. He died on 26 July 1972 at the 'Carnossa' Hospital, Oxley, Queensland.

KLAUS ROHDE (1932–)

Klaus Rohde (Fig. 40) was born in Brandenburg/Havel, Germany, on 30 March 1932. He received his schooling at the Nikolai-Schule and the Saldria-Gymnasium in Brandenburg, completing his Abitur in 1949. He proceeded to Teachers' Training College in Brandenburg, graduating in 1950 with a Teacher's Diploma in Russian language. In 1950 and 1951 he attended the University of Potsdam where he studied Slavic languages. In late 1951 he enrolled at the University of Münster/Westphalia in West Germany to study zoology, botany, physiological chemistry and physics. In 1954 under the supervision of Prof. B. Rensch, Rohde carried out PhD research on the behaviour and physiology of *Paramecium*. In 1957 Rohde was awarded his Dr rer.nat (PhD) *magna cum laud,* by the University of Münster, a paper arising from his research being published the following year (Rohde, 1958).

From 1960 to 1967 Rohde took an academic position at the University of Malaya, supervising one MSc, two PhD, and several BSc Honours students (Rohde & Lee, 1967; Rohde, Lee & Lim, 1968). He was elected as the 3rd President of the Malaysian Society of Parasitology and Tropical Medicine, his predecessors being Prof. Sandosham and Prof. Desowitz.

Rohde was awarded his Habilitation from the Universität Bocum in 1970, and from 1970–1972 he was appointed as a post-doctoral Research Fellow to the Department of Parasitology at the University of Queensland (the department's first Research Fellow), to conduct research on the ultrastructure of monogeneans. From May to December 1972, Rohde was Reader in Zoology at the University of Khartoum, Sudan. Here he taught first to fourth year students, and accompanied a Cambridge University Research

group on an expedition to the Red Sea to study reef ecology. In January 1973, when it became clear he would not be appointed to the Chair of Zoology at Khartoum, Rohde returned to the University of Queensland to take up appointment as Director of the Heron Island Research Station on the Great Barrier Reef. Here he stayed until February 1976, when he was appointed as a lecturer in the Department of Zoology at the University of New England (UNE) in Armidale, New South Wales. He was promoted to Associate Professor in 1978 and was awarded a Personal Chair in 1993. In 1996 he received the UNE Vice Chancellor's inaugural award for excellence in science, as well as of the Clarke Medal of the Royal Society of New South Wales.

Rohde's 350 publications embrace research on ecology, zoogeography, development, speciation and ultra-structure of marine parasites, and parasites of tortoises. Included in these are major contributions to several books. He has undertaken research visits to the Red Sea, North Sea, Brazil, Uruguay, Argentina, Mexico, Papua-New Guinea, Southeast Asia, New Zealand, South Pacific Islands, Canada, Hawaii and many places along the southern and eastern coasts of Australia. Additionally, he has been a Visiting Professor at the Universidad Nacional Autonoma de Mexico, November–December 1987, and a Visiting Research Fellow at the Smithsonian Institute, US National Museum Washington, December 1987–January 1988.

Since 1979 Rohde's scientific expertise has been utilised as a Member of four editorial boards of scientific journals: these being: *International Journal for Parasitology* 1979–1984; *Malaysian Journal of Science* 1994, *Acta Parasitologica* 1994–; *Folia Parasitologica* 1994–. He was a subject editor of *Diseases of Aquatic Organisms* from 1985–1986, and has been an advisor to that Journal since 1986.

Rohde is an elected Fellow of the Institute of Biology (1985), the Australian Institute of Biology (1987), and the Australian Society for Parasitology (1998). He has been a member of the selection committee for the Bancroft-Mackerras Medal (*q.v.* Sprent's biographical note for details of this medal) 1989–1990, 1996 and 1999, and Chairman of said Committee in 1990–1991. He has supervised many PhD, MSc and BSc Honours students at the Universities of Malaya, and of New England. Rohde has published descriptions of 1 new subfamily, 7 new genera and 32 new species.

KIM BRADLEY SEWELL (1957–)

Kim Sewell (Fig. 66) was born in Brisbane on 16 November 1957. On leaving school, he in 1973 pursued musical interests and casual work before joining the Department of Parasitology at the University of Queensland in 1976, working at their Veterinary Farm at Pinjarra Hills (Fig. 24) as an animal attendant. From 1977 to 1984 he maintained colonies of experimental animals used by parasitology researchers, while studying part-time towards a BSc, with majors in parasitology and zoology (awarded in1985).

In 1984 Sewell was promoted to Scientific Assistant working in the Marine Parasitology section with responsibility to collect marine specimens for use in laboratory practical classes. He also acted as a laboratory tutor from 1984 to 1989, instructing students in laboratory safety and protocol, and assisting with the identification of marine parasites recovered from freshly caught fish, crustacea and invertebrate hosts.

In 1986 Sewell enrolled in an honours project in marine parasitology, and after two years part-time study was awarded First Class Honours (Sewell, 1988). Sewell collaborated with R.J.G. Lester in producing a checklist of parasites from Heron Island (Lester & Sewell, 1989). In addition to carrying out deep sea trawl-fishing off southeast Tasmania for his own honours project, he participated in investigations into parasites as population markers for three southern Australia species of deep-sea trawl fish, *Hoplostethus atlanticus* (orange roughy) (Lester, Sewell *et al.*, 1988), *Macruronus novaezelandiae* (blue grenadier/hoki) and *Rexea solandri* (gemfish) (Sewell & Lester, 1995). Following his Honours, Sewell was promoted to Scientific Officer, and as such acted as a research assistant on a variety of projects, including investigations into parasites of the abalone (Goggin, Sewell & Lester, 1989, 1990; Lester, Goggin & Sewell, 1990).

In 1989 Sewell joined the Queensland Museum as a Museum Technician, working with Dr L.R.G. Cannon, Senior Curator of Worms. Here his duties involved maintenance of the collections as well as carrying out field work, and assisting in research projects. Beginning in May 1990, he provided dedicated assistance to the building of the Australia-wide database of parasite collections (ASPIC). He accompanied Cannon on an Australia-wide visit to those institutions which boasted parasite collections, photocopying their records and liaising with their curatorial staff.

Sewell redesigned the computer database for zoological and parasitological collections which Cannon had originally designed (see part A). Sewell then logged in more than 15,000 new invertebrate specimen lots. With the acquisition of the International Reference Centre for Avian Haematozoa from Canada, Sewell redesigned their database of some 120,000 records, so as to incorporate them into ASPIC.

At the same time as beginning work at the QM, Sewell enrolled to undertake a PhD at the University of Queensland. He chose co-supervisors — Dr Ian Whittington in the Department of Parasitology, and Dr Mike Bennett from the Anatomy Department. Sewell chose to study temnocephalans, specifically *Craspedella pedum* as a model for ectosymbiosis (Cannon & Sewell, 1994, 1995; Sewell & Cannon.1995; Sewell & Whittington, 1995a). During the years leading up to the award of his PhD, Sewell specialised in studies on the biology, functional morphology and systematics of temnocephalan and turbellarian worms. His project was greatly assisted in 1994 by the six month visit to the Queensland Museum by Russian scientists, Dr Boris Joffe, and his wife Dr Irina Solovei. Joffe is an anatomist, morphologist and phylogenist who has published extensively on temnocephalans. Solovei is a cytogeneticist who is also a brilliant electron microscopist. At Cannon's invitation, they came to the Queensland Museum on an ARC grant, to help him elucidate relationships between temnocephalan worms. Sewell became involved with the collaborative research being carried out by Cannon, Joffe and Solovei, especially studies on the organisation of the epidermal syncitial mosaic (Joffe, Solovei, Sewell & Cannon, 1995).

In 1991, Sewell undertook a short practical course in transmission electron microscopy (TEM) at the University of Queensland to assist him with his own research. This enabled him to collaborate with Nikki Watson and Prof. Klaus Rhode at the University of New England in studying the ultrastructure of spermiogenesis and spermatozoa of six temnocephalans (Watson, Rohde & Sewell, 1995).

Sewell was awarded his PhD in 1998, but with no prospects of professional progression at the Queensland Museum, decided to pursue a career in secondary school teaching. He enrolled in the Graduate Diploma of Education at the University of Queensland in 1998 specialising in junior science and multi-strand science and biology. He held a position at Toogoolawah school as a science master, but in 2002 he took a year off to assist Cannon and others in an ARC funded study of the co-evolution of temnocephalans and crayfish. He currently works as a technical officer at the Centre for Microscopy and Microanalysis, at The University of Queensland.

DAVID MICHAEL SPRATT (1942–)

David Spratt (Fig. 20) was born in Toronto Canada on 30 July 1942. He graduated with a BSc from the University of Toronto in 1965, and was awarded a Province of Ontario Robarts Scholarship to commence studies for an MSc under the joint supervision of Dr Roy C. Anderson and Dr Murray Fallis of the Ontario Research Foundation. The MSc was awarded in 1966 for his studies on the guinea pig as an experimental host of the meningeal worm, *Parelaphostrongylus tenuis*, of white-tailed deer (Spratt, 1966).

A WHO scholarship in the Department of Parasitology at the University of Queensland, prompted a move 'down under' in 1967 to commence a PhD under Prof. John Sprent. In 1969 a University of Queensland Overseas' Student Scholarship assisted in completion of this work, and Spratt graduated in 1970 for his field, enclosure, and laboratory studies of the life history and epidemiology of the nematode *Pelecitus* (= *Dirofilaria*) *roemeri*, in kangaroos, wallaroos and wallabies (Spratt, 1970b). He was able to demonstrate the role of day-biting tabanid flies as intermediate hosts, and transmission vectors, for *P. roemeri*, confirming the suggestion of Harvey Johnston and Josephine Bancroft. In 1920, these authors had found larval filariae described as *Agamofilaria tabanicola*, in 3.5 per cent of 500 tabanid flies dissected during a search for the vector of *Onchocerca gibsoni*, a parasite of cattle at Eidsvold (Spratt, 1970a). An Australian Research Grants Committee Postdoctoral Fellowship during 1971–1973, supported further studies of *P. roemeri* in macropodid hosts and a taxonomic revision of the filarioid nematodes from Australasian marsupials (Spratt, 1972a, b, 1974, 1975).

In November 1973 Spratt joined the CSIRO Division of Wildlife Research in Canberra to initiate a program of research to assess the effects of the planned introduction of anoplocephalid cestodes and lung nematodes into populations of rabbits in Australia, and to develop systematic and life history studies of the parasite fauna of native Australian animals, with assessment of their potential role in host ecology. This project came to an end when they were able to demonstrate that

rabbit lungworms also infected sheep, and that the tapeworms did not consistently complete their life-cycle in Australian rabbits. In mid-1977 Spratt was promoted to Senior Research Scientist and instructed to turn his research energies to the parasites of native animals. He was assisted in this endeavour by the recipients of two CSIRO Postdoctoral Fellowships, initially Ian Beveridge, and later Tom Cribb.

For the next 24 years Spratt's interests centered on ecology, taxonomy and life cycles of nematodes, trematodes, cestodes, pentastomes, mosquitoes, midges, tabanids, fleas, ticks and mites of Australian vertebrates. He built up a fully documented and electronically databased collection of parasites of wildlife, as a basis of his own taxonomic studies, but also of great value to colleagues nationally and internationally.

He was promoted to Principal Research Scientist in 1982, and in 1990 became Officer-in-Charge of the headquarters of the Division of Wildlife and Ecology at 'Gungahlin' in Canberra. He was promoted to Senior Principal Research Scientist in 1993, and became the Assistant Chief of the Division, a role he filled until the end of 1997. During this period he served frequently as Acting Chief of Division while the Chief was absent in his role as Director of the Global Change and Terrestrial Ecosystems Project of the International Geosphere-Biosphere Program. Spratt was in charge when the biological control agent, rabbit calicivirus, escaped from Wardang Island, an experience which provided him with unwelcome but enduring memories of some of the inner workings of federal government.

Spratt retired in December 2000, but continues as a post-retirement research fellow in CSIRO Sustainable Ecosystems. His particular emphases are on taxonomy, and analyses of his long-term study of the succession of small mammal communities following wildfire and the re-colonisation and re-structuring of their ecto- and endo-parasite communities in temperate eucalypt forests.

JOHN FREDERICK ADRIAN SPRENT (1915–)

The following biographical note has been compiled from information gleaned during some lengthy and enjoyable discussions with Prof. Sprent. The account is more extensive than others since John has been such a driving force behind parasitology in Queensland, and indeed Australia, over the last half of the 20th century.

John Frederick Adrian Sprent (Figs 29, 63, 64, 65) was born in London on 23 July 1915, the eldest son of a family of three. His father was Keeper of Ancient Maps at the British Museum, an institution with which he was to form a lifelong association. Trained as a veterinarian at the Royal Veterinary College in London, he gained his MRCVS diploma in 1939, with the Coleman Silver Medal in Veterinary Medicine, and a Gold Medal in Pathology. He applied to the Colonial Service for a cadetship to enable him to study for a university degree, electing to specialise in protozoology for 12 months with Dr Llewellyn Lloyd at the University of Leeds, and helminthology for a further 12 months with Dr Nellie B. Eales at the University of Reading. At the end of that time he presented himself for examination by the University of London for the external degree of Bachelor of Science (Zoology), which he was awarded with First Class Honours in 1942.

NIGERIA. Following graduation, Sprent was consigned by the Colonial Office to Vom Veterinary Station (Fig. 63) on the Bauchi Plateau, Nigeria. Assigned to investigate the 'roundworm in pigs', he found it to be only a minor problem, but did find many roundworms in young calves, which he identified as *Neoascaris* (now *Toxocara*) *vitulorum* (see Sprent, 1992). Prior to venturing into field work, he spent his first few days at Vom examining the water from a ditch near his house on the station (Sprent, 1982b). Finding the water samples to contain fork-tailed cercariae, he informed the director at Vom of the possibility of schistosomiasis. Alarmed, the director asked Sprent to stay on a bit longer and write a report on the situation. Several days later, one of the stockfarm cattle died, and on autopsy it revealed a heavy hookworm burden and generalised anaemia. Another report was called for, and the ensuing research stretched into a two-year project working on *Bunostomum phlebotomum* (hookworms) in cattle (see Sprent, 1946a, b, c).

At the veterinary laboratory in Vom, young cattle were purchased from native owners to produce anti-rinderpest serum. Sprent surveyed 250 of them for helminths and for any lesions which might have been caused by them, searching the carcasses at the rate of 20 per month (see Sprent, 1946d). The aim was to gauge whether poor body condition and anaemia were related to helminth burden. Whilst on leave in England in

1945, Sprent submitted an account of his studies of *Bunostomum phlebotomum* to the University of London to be assessed as a PhD, and was awarded the degree in that year.

Sprent had been awarded a post-graduate scholarship on first obtaining his BSc in 1942, but this had been deferred until 1946. Applying for three years leave from the Colonial Office, beginning on 31 March 1945, Sprent took up the scholarship and spent the next year as a Research Fellow of the Ministry of Agriculture in Weybridge, England (Sprent, 1946e).

UNIVERSITY OF CHICAGO. In 1946 he left England to spend the last two years of his leave at the University of Chicago as Cooper Centenary Research Fellow of the Veterinary Education Trust working with Prof. W.H. Taliaferro, well known for his pioneering work in parasite immunology. His interest became focussed on studies on *Ascaris suum* in relation to the immunological response of the host (see Sprent, 1949; Sprent & Chen, 1949b) and thus began a lifelong interest which was to lead to his becoming a world authority on the Ascaridoidea.

In the summer of 1947 he met Prof. Murray Fallis at the American Society of Parasitologists' conference in Chicago (Fallis, 1993a). Fallis was head of the Department of Parasitology at the Ontario Research Foundation in Toronto, and also a staff member of the School of Hygiene at the University of Toronto, whose Department of Microbiology incorporated parasitology (Fallis, 1993a). This meeting led to Sprent's appointment as a Senior Research Fellow at the ORF in 1948 (Fallis, 1993a), following his resignation from the Colonial Service (Sprent, personal files, 1948).

ONTARIO RESEARCH FOUNDATION, TORONTO. In Ontario, Sprent continued his immunology studies of *Ascaris suum* begun at the University of Chicago (Sprent, 1950a, 1951c), and he also set about defining morphological differences between the pig ascarid, which we now know as *Ascaris suum*, and the human ascarid, *A. lumbricoides* (Sprent, 1952b).

Sprent found many other ascaridoid species in fur-bearing animals in Ontario that were new to him (Sprent, 1950b, 1951c), and continued his immunity studies on these species. He identified a new species in the fisher and marten, which he called *Ascaris* (later *Baylisascaris*) *devosi* (see Sprent, 1952d, 1953b), and investigated species in other mammals including lynx, bear, raccoon and wolf (Sprent, 1982b). John Pearson, a PhD student of Murray Fallis, recalls many mammals being offered for study. On one occasion fifty frozen wolf carcasses, collected by bounty hunters, arrived at the laboratory. Frozen and inoffensive on arrival, the smell was indescribable once the carcasses thawed (Pearson, pers. comm.).

Sprent's studies of the various species of ascaridids in the native Canadian mammals led to his discovery that the larvae of each *Ascaris* species has a characteristic migratory pattern in rodents, becoming lodged in a variety of preferred sites, such as muscle, eye, brain or heart. They are then able to remain there, quiescent, for a number of years (Sprent, 1950b). Thus these *Ascaris* utilise intermediate hosts (somatic migration) as opposed to the direct life cycle of *Ascaris suum* first established by Roberts (1935) working in Brisbane. Roberts demonstrated that pigs become infected with *Ascaris* by ingesting embryonated eggs that then hatch in the intestine, migrate through the liver and lungs and return to the intestine by way of the trachea and oesophagus. Sprent (1952c) termed this migratory behaviour 'tracheal migration' to differentiate it from somatic migration.

Sprent was working in cooperation with Tiner[30] at the University of Illinois who had demonstrated that *Ascaris columnaris* utilises an intermediate host to infect raccoons (Tiner, 1949). To establish which ascaridoids underwent tracheal migration, as opposed to somatic migration, Sprent infected mice with the embryonated eggs of a variety of *Ascaris* species. His findings were that *Ascaris lumbricoides, A. suum* and *Parascaris equorum* all underwent tracheal migration (Sprent, 1952e). All other species investigated underwent somatic migration, in which there was more or less permanent infection of the rodent with encysted but living larvae. These encapsulated larvae would only mature on being eaten by a carnivorous host. The work indicated that ascaridoid nematodes of nearctic carnivores occurred in two tiers of hosts: the larvae in the prey (usually rodents) and the adults in the predators (Carnivora). In Sprent's own opinion the paper in which he reported these results (Sprent, 1952e) was his most important because it complemented the concept of 'visceral larva migrans', a term introduced by Prof. Paul Beaver and his associates (Beaver *et al.*, 1952) for lesions produced by parasite larvae in the human host. Further investigations demonstrated that larvae of ascaridoid parasites of carnivores remain alive in the tissues of mice for at least six months (Sprent, 1953c).

FIG. 63. Prof. J.F.A. Sprent: A, as a veterinary science student in England, ca. 1936; B, Newly-weds, John and Muriel Sprent, London, England, 1936; C, his first career appointment was with the British Colonial Service as a research veterinary officer at Vom, Bauchi Platcau, Nigeria. Pictured is the Agricultural Station where he spent three years, 1943-1946; D, instructing a Nigerian student in microscopy; E, taking a blood sample from a calf infected with hookworm, *Bunostomum phlebotumum*.(All Courtesy of Professor J.F.A. Sprent).

Sprent (1954) proposed that life cycles of ascaridoids are primarily indirect. He postulated that *Ascaris lumbricoides* was highly evolved, with its migration via the liver and lungs to intestine, being an evolutionary modification for living in herbivorous hosts. From the lungs, there are two pathways. 1) Tracheal migration (no intermediate host); effective in herbivorous animals, and utilised by *Ascaris lumbricoides, Ascaris suum, Parascaris equorum*; from the lung capillaries they break out into the alveoli, and via the bronchioles, are coughed up and then swallowed, maturing in the intestine. 2) Somatic migration (with intermediate host); typical in carnivorous animals; from the lungs, larvae travel via the circulation (pulmonary vein) to the tissues, become encapsulated; maturation only occurs when eaten by a carnivorous host.

Sprent suggested that the use of intermediate hosts was a primitive characteristic, radiation having originally occurred amongst marine animals through the use of marine invertebrates and fish as intermediate hosts. He suggested further that the spread to terrestrial animals may have occurred through coprophagous animals such as rodents swallowing ascaridid eggs from the faeces of littoral animals, and, by harboring encysted larvae in their tissues, rodents may have become intermediate hosts for the ascaridoids of many terrestrial carnivorous animals. In extending their range to non-carnivorous hosts, the ascaridids have modified the migratory behaviour of the larvae so as to dispense with intermediate hosts and promote infection of the final host through the ingestion of embryonated eggs (Sprent, 1954).

The publications arising from Sprent's research at ORF earned him the award of the prestigious Doctor of Veterinary Science degree by the University of London, in 1953.

THE UNIVERSITY OF QUEENSLAND. While he felt his work was progressing satisfactorily in Canada, he aspired to establish his own laboratory. For this reason he applied for a lectureship in parasitology at the Veterinary School, University of Queensland, recently re-opened following its closure during World War II (English, 1986). Sprent was appointed to the position in 1952. In 1954, Sprent became Research Professor of Parasitology in the Department of Veterinary Anatomy and Parasitology. Following a grant being made available by the Reserve Bank in July 1956, he was appointed Professor of Parasitology (University of Queensland Archives, Staff files, 1956). From 1960 to 1963 he was Dean of Veterinary Science at the University of Queensland.

In July 1961, Sprent's bid to establish a separate Department of Parasitology became a reality (University of Queensland Archives S130). Staff members were strategically recruited for their expertise in fields of research which would be of on-going benefit to Queensland in particular, and Australia in general. The new department was to offer broad-based training of a high standard. From its establishment in July 1961 until 31 December 1998 when it became integrated with the Department of Microbiology, the following post-graduate degrees were awarded: 28 Master of Science/Agricultural Science/Veterinary Science degrees; 120 PhD degrees; one Doctor of Medicine, four Doctor of Science, and six Doctor of Veterinary Science degrees.

SPRENT'S CONTRIBUTION TO IMMUNOLOGY. Sprent pursued the theory of immunology in relation to parasitism in three publications. The first paper was 'Parasitism, Immunity and Evolution' comprising a chapter in *The Evolution of Living Organisms* (Sprent, 1962a). Sprent had recently read, and been influenced by Macfarlane Burnet's *Clonal Selection Theory* (Burnet, 1959) of antibody formation. This proposed the existence of predetermined antibodies, and gave antigen an elective role[31]. Sprent (1962a) suggested that a strategic adaptation to parasitism would be avoidance of recognition by the host through modification of antigenic structure, becoming as similar to the host as possible, so they would not elicit an immune response. A long-standing association between host and parasite would thus result in an immunological equilibrium — 'adaptation tolerance' (Sprent, 1964).

The second publication was Sprent's book *Parasitism* (Sprent, 1963b) wherein he further developed his 'adaptation tolerance' theory. He also made an immunological comparison between 'heteroparasites' (parasites in the accepted sense, which differ specifically from the host), and 'homoparasites' (grafts, tumours and foetuses which belong to the same species as the host). The third publication was the chapter 'Evolutionary Aspects of Immunity in Zooparasitic Infections' in Volume 1 of *Immunity to Parasitic Animals* (Jackson, Herman & Singer, Eds, 1969).

ASCARIDOIDS IN DOGS AND CATS. On joining the Veterinary School at the University of Queensland, Sprent initially focussed his

research on the ascaridid infections of domestic animals (see Sprent, 1955d, c, 1956, 1957a, 1958, 1959a; Sprent & English, 1958). Later he extended the research begun in Ontario on somatic migration of some ascaridoid species in the mouse (Sprent, 1951c) to explore the larvae's effect on the host's central nervous system. Thus he sought approval from the Quarantine authority to bring to Brisbane from Ontario, charcoal cultures of ascaridoid eggs of numerous species, viz. *Ascaris columnaris*, *A. devosi; Toxocara canis*, *T. cati*, *Toxascaris leonina*, *T. transfuga* and *Parascaris equorum*. Using these ascaridoid eggs, and stimulated by the discovery by Beautyman & Woolf (1951) of an ascaris larva in the brain of a child, Sprent (1955a, b) found that the various species showed striking differences in abundance in the brain of infected mice. Furthermore, *T. canis* larvae remained alive in the brain up to six months after infection. Sprent's (1955b) report on the pathological effects caused to the brain by the six ascaridid species, was relevant to the understanding of visceral larval migrans of other ascaridid infections that may cause human disease, e.g. *Baylisascaris* larva in North America and Tasmania.

From the mid-1950s, Sprent extended his investigations on the migration and development of ascaridoids by focussing his attention on those in reptiles, since there had been little research on life history patterns of that group.

ASCARIDOIDS IN SNAKES. Sprent's conclusion that the use of intermediate hosts was widespread throughout the ascaridoids (Sprent, 1956, 1958, 1959a), was further investigated through research into the migration and development of ascaridoid nematodes of snakes (Sprent, 1955c, 1959b). Initial investigations began with the carpet python, *Morelia spilota variegata*, whose ascaridoid nematodes include *Ophidascaris moreliae* Sprent, 1969, and *Polydelphis anoura* (Dujardin, 1845), and a new species he described with J.J. Mines, *Ophidascascaris* (= *Amplicaecum*) *robertsi* Sprent & Mines, 1960 (Sprent, 1963c; Sprent & McKeown, 1979). The larvae of *O. robertsi* mostly restrict their migration to the liver of the intermediate host.

Sprent (1963d) identified the natural intermediate hosts of *O. robertsi* as being native rats, bandicoots and other marsupials on which the carpet python preys, however he also showed that there may be no less than three intermediate hosts. The snake is at the apex of a food-pyramid that has at its base a variety of animals ranging from earthworms to herbivorous mammals. The larval stages grow at different rates in different hosts, and there is a progression through the pyramid, the higher the parasite ascends the pyramid, the greater being its host specificity. He also showed (Sprent & McKeown, 1967), that in their natural intermediate hosts, growth of the 3rd stage larvae of *O. robertsi* was significantly greater than in non-indigenous animals such as guinea pigs, rabbits and rats. This he suggested is an example of adaptation tolerance. On ingestion of the rodent by the python, further development of the larvae in the snake did not occur unless the larvae had attained a length of 20mm before ingestion, so only certain animals would be likely to act as functional intermediate hosts. Third stage larvae of *Ophidascaris robertsi* less than 20mm, may fatally penetrate the great blood vessels and heart, because the larvae have been ingested at a stage at which they are unable to develop in the alimentary tract.

The larvae of *Ophidascaris moreliae* do not grow in length in the tissues of mice or snakes, and migrate to the lungs where they cause granuloma and abscess formation in the wall of the lung.

Sprent (1982a) subsequently amplified his conclusions by considering the distribution of ascaridoids among their vertebrate hosts. He divided them into two categories, depending on the host's mode of nutrition: a) those in herbivourous hosts, both terrestrial and aquatic, which exhibit a narrow range of host-specificity; or b) those in carnivorous hosts (where the majority of ascaridoids fall). Carnivores become infected on ingestion of prey harboring immature ascaridoids in their tissues. Such prey include both vertebrates (fish, frogs, lizards and small mammals), and invertebrates, in particular, earthworms, crustaceans, molluscs and insects.

Sprent's final studies on ascaridoids of snakes were carried out on two species from New Guinea pythons, *Ophidascaris nuiginiensis* from *Chondropython viridis*, and *Liasis albertisi* and *O. papuanus* from *Liasis amethestinus* (see Sprent, 1973). The site and degree of growth of these ascaridoids in experimentally infected mice were different from that observed in infections with other species.

Sprent (1988) revised the genus *Ophidascaris* and divided it into five groups of species. Group 1: the filaria group occurring in pythons (see above) with eight closely similar species. Group 2: the

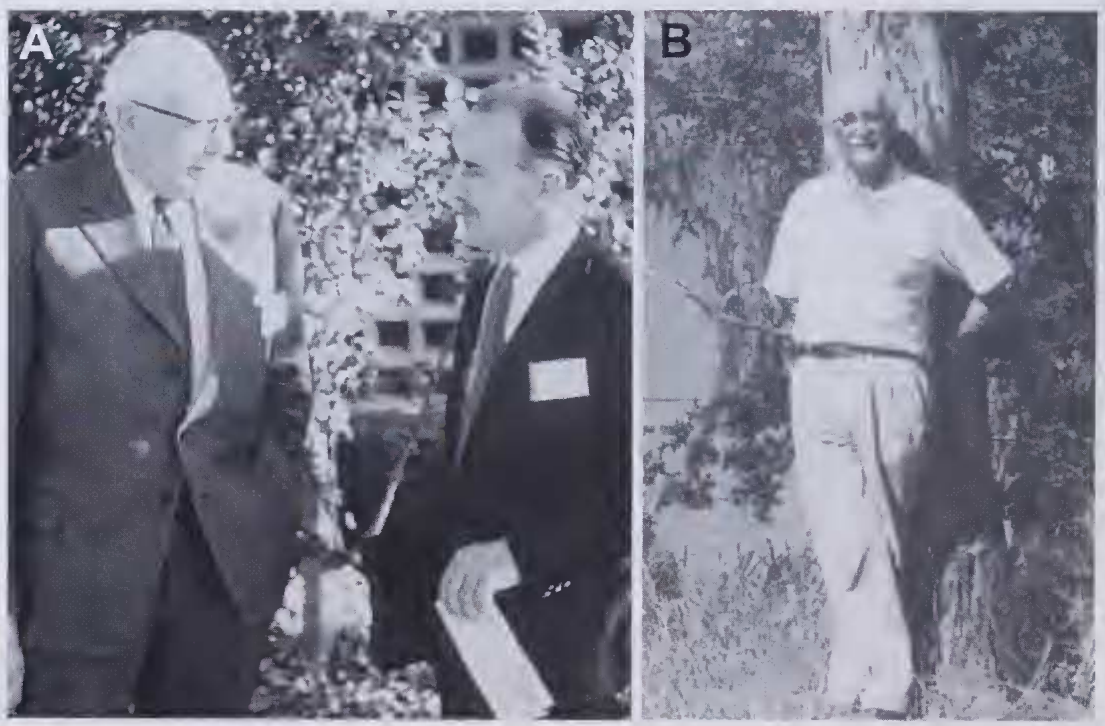

FIG. 64. Prof. J.F.A. Sprent: A, with Professor J. Bauer at the University of Queensland, ca. 1969, B, Amongst the eucalypts bordering the river on his property at Moggill, ca. 1998. A, Courtesy Prof. J.C. Pearson; B, Photograph by B.M. Angus).

'*obconica*' group, occuring in colubrid, elapid and viperid snakes, that includes *Ophidascaris ashi* (formerly *O. labiatopapillosa*). Group 3: the '*radiosa*' group in African viperids. Group 4: the '*najae*' group in African elapids and Asian elapids and colubrids. Group 5: the '*arndti*' group in South American crotalids and colubrids.

ASCARIDOID NEMATODES OF AMPHIBIANS AND AQUATIC REPTILES. In crocodilians Sprent redescribed seven species and described nine new species *Dujardinascaris* (see Sprent, 1977b, 1998). Similarly in marine turtles he redefined the genus *Sulcascaris*, redescribed *Sulcascaris sulcata* Rudolphi, 1819 (see Sprent, 1977c), and proposed a new species, *Goezia holmesi* (see Sprent, 1978a).

After examining freshwater turtles in Eastern Australia, Sprent (1980a) erected a new genus, *Krefftascaris*[32] and described a new species, *K. parmenteri*. *Krefftascaris* is the only ascaridoid genus so far known to occur exclusively in the Australian region. The family Chelidae, to which the host turtles belong, though not exclusive to the Australian region, are of Gondwanan distribution, occurring in both the Neotropical and Australian regions.

Sprent (1983a, 1990a, b) considers that the genera of ascaridoid nematodes fall within two families of the superfamily Ascaridoidea, the Ascarididae and the Crossophoridae. The Ascarididae comprises six subfamilies containing most of the species occurring in terrestrial, fluviatile and marine hosts.

Sprent (1990b) later reviewed ascaridoid species reported from freshwater fishes, and that he had previously relegated to genera within the Heterocheilinae (Sprent, 1983a), namely: *Dujardinascaris malapterurі* (Baylis, 1923) from *Malapterurus electricus* in Africa; *Brevimulticaecum regoi* from *Potamotrygon motoro* in South America; *Brevimulticaecum heterotis* (Petter, Vassiliadès and Marchand, 1979) from *Heterotis niloticus* in Africa; *Brevimulticaecum scleropagi* Khalil, 1984 from *Scleropages leichardti* and *S. jardini* in Papua-New Guinea and Australia. These species closely resemble those occurring in crocodilians in the same region, and Sprent (1990b) expressed the view that these

FIG. 65. Prof L. Ash and Dr B Angus with Prof Sprent (2002).

heterocheilinae species are secondarily derived from related species in crocodilians.

EDITOR-IN-CHIEF OF THE INTERNATIONAL JOURNAL FOR PARASITOLOGY. Between June 1974 and December 1993, Prof. Sprent was Editor-in-Chief of the *International Journal for Parasitology,* a journal sponsored by the Australian Society for Parasitology. In this undertaking, Prof. Sprent was greatly assisted by his long-time personal assistant and librarian, Miss Mary Cremin, who was appointed Assistant-to-the-Editor from June 1977, a position from which she retired on Sprent's relinquishing his office as Editor-in-Chief in December 1993. For her contributions to parasitology research, Mary Cremin was elected a Fellow of the Australian Society for Parasitology in 1985, and in 1986 was awarded a Medal of the Order of Australia (OAM).

Although retiring from the Chair of Parasitology in 1983, Sprent actively continued in his role as Editor-in-Chief of the *International Journal for Parasitology* for another ten years, and in his research activities for another fifteen years, his final publication appearing in *Systematic Parasitology* in 1999 (Sprent, 1999). His invited addresses, lectures and publications in refereed journals and books total some 140 papers.

CONCLUDING REMARKS. In this chronological record of Prof. Sprent's scientific career we have endeavoured to reveal the remarkable contributions that Sprent has made to the field of parasitology, and in particular, to knowledge of the nematode worms within the superfamily Ascaridoidea. Since all of us received training in Sprent's Department of Parasitology at the University of Queensland, we sought the independent opinion of a colleague of Sprent's, Prof. Lawrence Ash of the University of California in Los Angeles (Fig. 65), himself an ascaridoid expert of international standing, and a former student of Prof. Paul Beaver at Tulane University, New Orleans, Louisana, U.S.A. Professors Beaver and Sprent had enjoyed a close collaborative friendship for many years. Indeed, in a personal letter from Prof. Beaver dated 9 March 1989, he pays tribute to Prof. Sprent in the following paragraph: 'It is always a special pleasure to be reminded of the early work of John Sprent, Jack Tiner and the several fine workers who had the good fortune to study in the laboratory of the great Taliaferro. I can vividly recall the thrill and satisfaction I felt when those early discoverers

FIG. 66. The Queensland Museum team ca. 1999: A, Lester Cannon; B, Kim Sewell; C, Robert Adlard; D, Mal Bryant.

first became known to me as examples of the happiness one feels in the good fortune of others'.

Professor Ash wrote: 'John F.A. Sprent has been for some six decades a prodigious researcher and publisher on the biology, ecology, taxonomy and pathology of parasites. [...] This reviewer, having worked with many of the same or related parasites as Prof. Sprent, and having known him for some four decades, must comment specifically on one of the significant aspects of his long and noteworthy list of publications. Of more than 130 publications, it is rare to identify other authors on these papers. In these days of the norm of multiple authorship, his work stands out not for just the wealth of detail and understanding of the parasites he provided, but that he did the work and wrote the papers himself. On the other hand, students working in his laboratory pursued studies on these and other parasites of significance, but their papers when published typically did not carry his name. Certainly if he had insisted on this, his publications list would have been considerably longer. [...] In summary, Prof. Sprent's contributions to the parasitological literature and the insights he has provided to us in our understanding of host-parasite relationships for the ascaridoids and other parasites can only be considered to be remarkable. They reflect upon his commitment, work ethic and leadership, qualities that make him an ideal role model for current parasitologists as well as those in the future.' [Lawrence R. Ash, PhD. Professor of Infectious and Tropical Diseases, Department of Epidemiology, School of Public

Health, University of California Los Angeles, Los Angeles, California — Prof. Ash visited Sprent in late 2001 (Fig. 65)].

The J.F.A. Sprent Collection held at the Queensland Museum formed the nucleus of its parasitology collections, and it comprises the most important private collection of any one scientist at that repository. Prof. Sprent amassed a unique and beautifully catalogued collection of almost 8,000 nematodes, the bulk of which belong to the Superfamily Ascaridoidea. The position he holds as a distinguished scientist and as an international expert on the Ascaridoidea, is attested to by the honours conferred on him by numerous prestigious bodies at home and abroad [33].

1960: appointed a Fellow of the Royal College of Veterinary Surgeons, London.

1961: elected a Fellow of the New York Academy of Sciences; awarded the Payne Exhibition, University of Melbourne.

1962: presentation of the Henry Baldwin Ward Medal by the American Society of Parasitologists.

1964: elected a Fellow of the Australian Academy of Science.

1971: created a Foundation Fellow of the Australian College of Veterinary Scientists.

1973: elected a Fellow of the Australian Society for Parasitology, a Society which he originally formed, and of which he had been foundation President in 1964.

1981: awarded the Mueller Medal by the Australia and New Zealand Association for the Advancement of Science (ANZAAS).

1981: elected a Fellow of the Queensland Institute of Medical Research.

1983: the title 'Professor Emeritus' conferred on him by the University of Queensland

1985: invested at Buckingham Palace, London, with the Imperial honour of Commander of the Most Excellent Order of the British Empire (CBE).

IAN DAVID WHITTINGTON (1960-)

Ian Whittington (Fig. 67) was born on 19 September 1960 in Birmingham, England. In October 1979 he enrolled for a BSc, majoring in zoology, at the University of East Anglia, Norwich, Norfolk. In his final year he was stimulated by lectures on Parasitology delivered by Dr Graham Kearn, particularly in regard to the adaptation of monogenean parasites to fish hosts.

Obtaining his BSc with first class honours in July 1982, he was awarded a 4-year Science and Engineering Research Council scholarship to undertake a PhD under Dr Kearn, studying monogeneans from marine fishes. His field work was carried out each year at the Plymouth Laboratory of the Marine Biological Association. Awarded his PhD in October 1986 (Whittington, 1986), and with a publication arising (Whittington & Kearn, 1986), in January 1987 Whittington travelled to the University of Queensland, to take-up the offer of a two-year post-doctoral fellowship in the Department of Parasitology. From January to December 1989, he was an ARC Postdoctoral Research Fellow with a grant to work on parasites of lungfish, studying with John Pearson. This was followed from January 1990 to December 1992, by a Queen Elizabeth II Postdoctoral Fellowship to work on Monogenea of freshwater and marine fishes, principally using Heron Island as his research site.

Appointed as a lecturer in parasitology at the University of Queensland in January 1993, Whittington actively continued his research into monogeneans for the 5-year fixed term appointment. In October 1994, and again in January 1995, Whittington was Acting Head of the Department of Parasitology, and between 1996 and 1999 he was Director of the University's Heron Island Research Station. During this time he was a member of the Organising Committee for the 75th Meeting of The Australian Coral Reef Society. In June 1997 he was promoted to Senior Lecturer in Parasitology, continuing in this position when that department was subsumed into the Department of Microbiology and Parasitology in January 2000. In July 2001 Whittington chaired the Organising Committee for the Fourth International Symposium on Monogenea held in Brisbane.

Since joining the University of Queensland in 1987, Whittington has supervised and co-authored papers with six Honours students and four PhD students. Honours students include Diane Barton, now a lecturer at James Cook University of North Queensland; Sylvie Pichelin who proceeded on to PhD studies with Prof. J.C. Pearson, and who became Curator of Helminths at the South Australian Museum in Adelaide before returning to Queensland to marry Dr Tom

Cribb; Marty Deveney who was subsequently appointed to South Australia Aquaculture in Primary Industries, South Australia; Adam Fletcher who joined the Queensland Department of Primary Industries' Fisheries Division in North Queensland; and Tamarind Hamwood and Priya Pitt, both of whom proceeded on to PhD studies. His PhD students include Dr Leslie Chisholm who became a Research Associate of Whittington's, working on the Monogenea; Dr Kim Sewell (then of the Queensland Museum); and Dr Ingo Ernst who continued in Whittington's group as a Research Associate, and also as an Australian Postdoctoral Fellow (Industry) working on Monogenea, especially applied problems in aquaculture.

In December 2001 Whittington took up a new position as Research Scientist with the South Australian Museum, with conjoint affiliation with the University of Adelaide. His monogenean group followed him to Adelaide to continue their research from this new base. Whittington is author or co-author of 110 peer-reviewed publications. He has contributed presentations at 75 scholarly meetings, being an invited speaker at ten of these meetings. He has authored three book chapters, and edited one conference proceedings. Since 1988 he has obtained research and funding grants exceeding $2.8 million. He is currently a Principal Research Scientist at the South Australian Museum, and an Associate Professor in the Department of Zoology, University of Adelaide.

FIG. 67. Dr Ian Whittington.

PETER COLIN YOUNG (1940–)

Peter Young (Fig. 34) was born in Sutton, Surrey, England, on 9 February 1940. On leaving school he was awarded a Surrey County Scholarship for three years, to study at the University of London. He gained his BSc majoring in Zoology in 1962. Wishing to study for a PhD he proceeded to Imperial College at Silwood Park, London. Although his interest was in marine biology, Imperial College only offered entomology, zoology and parasitology as areas of study. Young's choice of an Honours in Parasitology allowed him the latitude to investigate parasites of a variety of fishes.

At Imperial College, a fellow student of Young's had been Pat Aldridge who had left to work in Hong Kong. When Prof. John Sprent, the foundation Professor of Parasitology at the University of Queensland, visited Hong Kong in 1962, he asked Aldridge whether he knew of '[...] an enthusiastic PhD candidate to work with Prof. Harold Manter from the University of Nebraska'. Manter was an expert on digenean trematodes of fish, and was going to be spending the next year on sabbatical at the University of Queensland. Aldridge suggested Young might be interested, and from 1963 to 1965, Young was the recipient of a University of Queensland Research Fellowship. Young accompanied Manter to Heron Island on the Great Barrier Reef, and to Stradbroke Island, where he caught fish for him (Fig. 39). According to Young, Manter 'tore the fish apart and found four to five parasites per fish'.

At the end of Manter's sabbatical, Young began to concentrate on the Monogenea trematodes. His original intention had been to investigate the ecology of the parasites and their hosts, but finding that nearly all of the species he looked at were new, he decided to become a taxonomist. He published nine papers from research conducted during his doctoral studies at the University of Queensland (Mawdsley-Thomas & Young, 1967; Young, 1967a, b, c, 1968a, b, c, d, 1969b, 1972b).

On completion of his PhD, Young was appointed as a Scientific Officer to the Commonwealth Bureau of Helminthology at St Albans in England, where he worked on ascaridoids in fish and

marine mammals (*Contracaecum, Anisakis* and *Terranova*). *Anisakis* ('herringworm') encysts in muscles and people become infected through eating uncooked herrings ('rollmops') (Young, 1969c). *Anisakis* also parasitises cod, which may harbour up to 40,000 larval worms in their stomachs. In this connection, Young surveyed grey seals around the British Isles, because the incidence in cod correlated with the presence of seal colonies (Young, 1972a). *Terranova* ('cod worm') is a bad pest because infestation with 2–5cm long nematodes can cause an entire catch of cod to be discarded (Young, 1969a). Young was curious to discover the worm's definitive host and whether it caused a public health problem. At the Oceanology International Conference in 1969, he and an Indian colleague from Egypt, Lotfi Khalil, presented a joint paper on these questions (Khalil & Young, 1969).

In 1970, Young returned to Queensland as a CSIRO Research Scientist in the Division of Fisheries and Oceanography at Deception Bay[34]. Thus began the second phase of Young's career: parasites, prawns (post-larvae), seagrasses and their epi-fauna, and scallops. Young was Project Leader of CSIRO's East Coast Prawn project, investigating mortality rates (Lucas, Young & Brundritt, 1972), managing crustacean production systems (Young, 1975a, 1978; Young & Carpenter, 1977), and investigating the zoogeography of penaeid (King) prawns (Young, 1975b). He was sole editor of the Proceedings of the *First Australian National Prawn Seminar* held at Maroochydore, Queensland, in November 1973 (Young, 1975c).

Co-incident with the prawn studies, coastal and estuarine seagrass communities were examined, and encompassing the epi-benthic communities of Moreton Bay (Young & Wadley, 1979; Sandland & Young, 1979; Kirkman & Young, 1981; Young, 1981: McMillan *et al.*, 1983). In 1978, he worked on seagrasses in the south of France, working out of the Lyon Station Marine d'Endoume in Marseilles.

From 1975 to 1980, Young was leader of a CSIRO ecology sub-program studying community ecology and pollution (Ward & Young, 1982). A main focus was on discovering the ecological drivers for near-shore epi-benthic communities, both in the tropical Torres Strait (Bridges, Phillips & Young, 1982; Bradbury & Young, 1983), and the temperate waters of South Australia (Ward & Young, 1981, 1983, 1984). In the mid-to-late 1970s Australia was leading the field in coral reef ecosystem structure and function (Bradbury & Young, 1981, 1983). From 1981, Young was group leader of CSIRO's Living Resources, Temperate Species Group, to which was added the Tropical Species Group in 1982. These studies continued through until 1985.

With Young as Project Co-ordinator (1982–1985), CSIRO'S Division of Fisheries initiated a study of prawns (Sandland & Young, 1983), and of fish populations on the North West Shelf, Western Australia (Young, 1985; Young & Sainsbury, 1985; Young *et al.*, 1986). Young observed that while hermaphroditism is a common feature among monogencans, it is also a feature of protogynous[35] fishes (Young, 1982 Report) (most fishes are protogynous, the majority of fish not having sex chromosomes, only genes). Young & Martin (1982) observed that male fish grow faster than female fish because they are changing sex (Young, 1982 Report); and in at least one species of fish, if the largest fish is removed, another will become bigger and change sex. Additionally, a whole age-matched group changes sex at the same time (Young & Martin, 1985). Between September 1984 and January 1985, Young was Officer-in-Charge of CSIRO's Division of Fisheries at Cronulla Marine Laboratories in Sydney before being appointed Program Leader of CSIRO's Fisheries Resources South and Southeast in 1985.

The fourth phase of Young's career concerned the scallop industry (Young & Martin, 1989; Young, 1989), with most of his research concentrated on population dynamics, and the change between reproduction and survival of the next generation (Young *et al.*, 1990, 1995; McCoughlin *et al.*, 1990; Young, 1992a, b).

Young was appointed Chief of CSIRO's Division of Fisheries in 1990 (Fig. 34), retiring from this position in 1996. In the course of his career, he has been the foundation Director of the Australian Fisheries and Management Authority (1992–1996), and of Aquaculture CRC Ltd. (1994–1996). Between 1992 and 1993 he was Associate Director of Australian Marine Science & Technology Ltd., and in 1993 was made an Honorary Research Professor of the University of Tasmania, occupying this position until his retirement in 1996.

In 1994, Young was awarded the Australian Minerals and Energy Environment Foundation review prize for the best review on existing literature on an environmental subject pertaining to the Australian Minerals and Energy Industries

(Swan, Neff & Young, 1994). In 1995 the inaugural K. Radway Allen Award of the Australian Society for Fish Biology, was awarded to him for sustained excellence in fish or fisheries science. Between 1995 and 1997, Young was President of the Australian Society for Fish Biology. He has been a CSIRO Special Research Fellow since 1997.

Since his retirement he has been commissioned as a specialist consultant to compile reports on matters of concern to the environment and to endangered species. Two such reports have been commissioned by the Queensland Commercial Fishermen's Organisation. One was to evaluate the state of knowledge and fisheries status of the East Coast Trawl Fishery (Young, 1999). The second to evaluate the scientific evidence supporting management proposals for dugong (*Dugong dugon*) (Young, 2000).

Young is the author or co-author of 50 peer-reviewed articles. He has been author or editor of nine significant books and published presentations, and 18 reports and popular articles. He now lives in retirement on acreage on the outskirts of Brisbane.

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We are indebted to Prof. Lawrence Ash, Professor of Infectious and Tropical Diseases at the School of Public Health, University of California in Los Angeles. Prof. Ash prepared a paper for inclusion in Sprent's biographical note which is 'an appreciation' of Sprent's tremendous contribution to the field of parasitology. With regret, this had to be considerably shortened in the final publication.

Professor J.C. Pearson is thanked for spending an entire morning being interviewed about his career in trematodology. He loaned two important books relating to the Ontario Research Foundation, that have provided much background material for this record, and he also contributed a photograph of a painting of the Ontario Research Foundation done by Dr Roy Anderson's uncle (reproduced herein). In addition, he has allowed us to include a number of important photographs of his early years at the Department of Parasitology in Brisbane during which he supervised post-graduate students who have achieved illustrious careers of their own — Howard Choat, Peter Young and Rob Ballantyne.

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APPENDIX

A BRIEF HISTORY OF THE DISCOVERY OF THE MALARIA PARASITE AND THE NATURE OF ITS TRANSMISSION

(See main Bibliography for literature cited in the text)

According to Foster (1965) '[...] our knowledge of the plasmodium of malaria is one of the most fascinating in the whole history of medicine'. Our discovery of the aetiology of malaria and its transmission occurred in three main phases. 1) Discovering the malaria parasite. 2) Understanding the development of the parasite in the human body, and the discovery of different species of human malaria. 3) Detailing the clinical presentation of the disease and how it differs between species; understanding the development of the parasite outside the human body, and realising that malaria is a vector-borne disease transmitted by mosquitoes.

The importance of studying certain types of malaria in birds was demonstrated conclusively little more than 100 years ago by Surgeon Major Ronald Ross working in India. His definitive studies of what he described as *Halteridium* in pigeons, and of *Proteosoma* in larks and sparrows, elucidated the vector-borne nature of malaria *per se*, and the mechanism of transmission of the disease.

'Vector-borne disease' refers to the fact that certain arthropods (vectors) are responsible for disseminating disease, with the disease organism typically undergoing part of its life-cycle in the vector. This is apposed to 'mechanical transmission' where the disease organism is simply transmitted via contaminated mouthparts. Arthropod vectors fall into two general groups: 1) Free-flying, e.g. mosquitoes, biting midges, black flies, tsetse flies; 2) Sessile, e.g. ticks, mites, lice, fleas, bugs, keds. These two disparate modalities must have been fundamentally important in the evolution of the disease systems, with selection pressures promoting adaptation to the vector, being more intense in free-flying vectors than in sessile ones (Mattingly, 1965).

Certain genera of parasites come to be rigidly associated with particular groups of arthropod vectors. It has been suggested that the evolution of mammalian *Plasmodium* species was via *Hepatocystis* (ceratopogonid (biting midges) vectors); and that avian plasmodiids have evolved via *Haemoproteus* (ceratopogonid and hippoboscid (keds, louse flies) vectors). This is relevant to vector specificity, for if avian and mammalian plasmodiids are the products of two separate evolutionary lines, this could explain the restriction of mammalian plasmodiids to anopheline mosquitoes and of avian plasmodiids to culicine mosquitoes (Mattingly, 1965). More than 50 species of malaria are known to occur in birds, lizards and mammals (Cheng, 1973). In humans however, malaria is confined to four species of the genus *Plasmodium*.

PLASMODIUM SPECIES IN HUMANS

The discovery of the human malaria parasite was made by Alphonse Laveran, a French Army doctor, who conducted painstaking research between 1878 and 1882 into the causative agent of the disease (Foster, 1965). He identified different forms of the parasite in the erythrocytes, and also noted the presence of distinctive pigmented elements in the blood (what we now term haemozoin[19]). In 1882, Laveran went to Rome where there were excellent research facilities and a high incidence of malaria. The Roman researchers were sceptical of Laveran's recognition of parasitic stages in the blood, regarding them instead as 'degenerate erythrocytes'. In 1884, Danilewsky observed exflagellation of the male microgametocyte in the blood of wild birds at Kharkov, Ukraine (Danilewsky, 1884), apparently unaware of Laveran's having four years earlier witnessed exflagellating microgametocytes in the blood from a malarious soldier in Algeria. Finally, in 1885, the Roman Professors Ettiore Marchiafava and A. Celli acknowledged the accuracy of Laveran's observations, prompting more research by other Italian scientists. In 1886 Camillo Golgi was the first to recognise a second distinct type of malaria parasite, each resulting in different fever cycles. He described these as benign tertian and benign quartan malaria. Subsequently Marchiafava and Amigo Bignami, identified a third, typically fatal 'malignant tertian' form (*Plasmodium falciparum*). Finally in 1894, Marchiafava published the descriptions of the four species we now recognise — *Plasmodium vivax, P. ovale, P. falciparum* and *P. malariae*. Though they now could recognise the species, the mode of transmission was still unknown.

THE SEARCH TO UNDERSTAND TRANSMISSION

In 1877, Patrick Manson in Amoy, China, had demonstrated that the human filarioid, that we now know as *Wuchereria bancrofti*, underwent development in the mosquito, *Culex fatigans* (= *C. quinquifasciatus*)(Manson, 1878). However, he mistakenly believed that transmission was via ingestion of water containing larval forms of the parasite. Manson suggested that mosquitoes may play a similar role in the transmission of malaria, though again, indirectly through contaminated water.

In 1894, during his leave from the Indian Medical Service, Surgeon Major Ronald Ross sought out Manson in London. Manson was familiar with Ross' reports on public health issues in India, and had been impressed by them. Manson showed Ross how to detect malaria parasites in human blood smears, and at the same time, impressed on him his own conviction that development occurred in the mosquito in a similar way to the human filarial parasite. He urged Ross, on his return to India, to undertake investigations into the significance of the crescents and flagellated bodies in malarial blood. It was Manson's advice and encouragement to 'follow the flagellum' of the malaria parasite in mosquitoes, that guided Ross in his painstaking studies in India.

Ross returned to India in 1895, and because the Indian Medical Service were reluctant to allow him to 'experiment' with army personnel, he recruited Indians from the local bazaar who were suffering from malaria. Uncontaminated mosquitoes, that he had raised from larvae, were allowed to feed on the Indians, and these (54 in total) were then dissected at increasing post-prandial intervals. Ross observed that the 'crescents' in the human blood underwent a rapid change to 'spherules' in the mosquitoes' stomach, and within three hours of the bloodmeal, the process of ex-flagellation had begun. He was unable in subsequent experiments to 'follow the flagellum' into the mosquitoes' tissues. To test Manson's idea that parasites were transmitted via water, Ross unsuccessfully attempted to infect people using water containing different forms of the parasite from mosquito stomachs. Ross told Manson that he was convinced the malaria parasite was transmitted by the bite of the mosquito —

a conclusion with which Manson still strongly disagreed.

Two years after returning to India, Ross investigated malaria problems in a valley called Sigur Ghat, in a different region of India. Again raising mosquitoes from larvae brought in by local Indians, and feeding them a contaminated meal, he found that this time while there were abundant 'psorosperms' in their stomachs, development of the parasite did not proceed further. Ross identified these different mosquitoes as *Culex sylvestris* and concluded that *Culex* species were thus not human malaria vectors. Continuing his experiments with different larvae, Ross observed that these metamophosed into adults with 'dappled wings' [anophelines]. Fed on malarious patients, dissection of these mosquitoes over a 5-day period yielded 'cells' which were not only clearly growing and increasing in size, but also contained pigment (later shown to be chromatin, or chromosomal material). These were different forms of cells from those he had seen previously, and the elated Ross realised that he had at last found the 'right type of mosquito' for the development of human malaria parasites[20]. His findings were published in *The British Medical Journal* in December 1897. Further such studies would have to wait because in August 1896, he had been posted to Kherwara where there was no human malaria. Instead, Ross decided to study the blood of frogs, toads, fishes and birds.

AVIAN MALARIA VECTOR RESEARCH. In December 1897 Ross identified a blood parasite, *Halteridium*, in the erythrocytes of a blue rock pigeon. *Halteridium* [*Haemoproteus*] had been first described by Danilewsky (1886) as an intracellular parasite of the red blood cells of birds, and he commented at that time that it was not unlike the human malaria parasite.

In February 1898, Manson alerted Ross to the findings of a medical student at Johns Hopkins Hospital, W.G. McCallum (McCallum, 1897), who had observed the process of conjugation between the flagellate male and the granular female bodies of *Halteridium*. Manson suggested to Ross that if the male element were a fertilising factor in the *Halteridium* life cycle, the flagellated body of malaria was also the fertilising body in the *Plasmodium* life cycle. In fact, Ross was dealing with the avian malaria parasite, *Plasmodium relictum*[21]. *Plasmodium* spp. undergo erythrocytic and tissue stage schizogony, compared with *Halteridium* spp. which only undergo tissue stage schizogony. Additionally, the vectors of *Halteridium* are hippoboscids and biting midges (Fallis & Wood, 1957; Fallis & Bennett, 1960a, 1961a; Khan & Fallis, 1971), whereas the vectors of *Plasmodium* are mosquitoes. However, Ross' work was undertaken prior to such knowledge. In addition to studying *Halteridium* in pigeons, Ross studied another blood parasite, *Proteosoma*, in the blood of larks and sparrows. This parasite was also found in the stomachs of the mosquitoes which plagued them. He observed that the developing 'coccidia' in the mosquito's coelom had a striated appearance which proved, on staining, to contain chromatin granules. He termed them 'germinal threads'. Furthermore, these 'germinal threads' (sporozoites) were in the thorax and head and '[...] especially numerous in the gland in front of the thorax' — the salivary gland.

On 6 July 1898, Ross reported to Manson that: 'Malaria is conveyed from a diseased person or bird, to a healthy one, via the proper species of mosquito, and is inoculated by its bite'. He demonstrated this with birds, and although he stated that, 'A single experiment with dappled wing mosquitoes would prove human malaria and *Proteosoma* were transmitted in the same way', he was unable to conduct this vital experiment himself, since the Indian Medical Service (IMS) had posted him to an area devoid of human malaria. On 28 July 1898, Manson reported Ross' findings to the Tropical Diseases Section of the British Medical Association and they were subsequently published by Manson on Ross' behalf in August 1898 in *The Lancet, The Journal of Tropical Medicine* and *The British Medical Journal.*

Despite Ross' breakthrough in demonstrating the natural mode of malaria transmission, the IMS was disinterested in his research. Frustrated, he returned to England, and in June 1899 he resigned from the IMS.

HUMAN MALARIA TRANSMISSION VIA MOSQUITOES IS PROVED. The Italian scientists Amigo Bignami and Giovanni Battista Grassi identified the 'dappled wing' mosquitoes as anophelines. This was the subject of much controversy because the Italians claimed not to have seen Ross' publications. They asserted that they had chanced on anophelines from collections of adult female *Anopheles claviger* made by a technician in a malarious locality outside Rome in October 1898. By 1 November 1898, Bignami, using these infected mosquitoes, had succeeded in 'infecting a volunteer with *Plasmodium falciparum*' (see Garnham, 1966).

Working with *A. claviger* Bignami and Grassi demonstrated that the human malaria parasites *Plasmodium falciparum* and *P. vivax* both underwent the same developmental process in anophelines as did *Proteosoma* in culicines.

In 1899, Professor Celli, a lifelong student of malaria and its epidemiology in the Campagna, further demonstrated the necessity of mosquitoes in the transmission of human malaria. He simply screened a hut against mosquitoes, and had the occupants remain indoors from sunset to sunrise. Those fortunate folk in the screened hut remained malaria-free, while those not so protected, contracted malaria. Patrick Manson repeated Celli's experiment by having the Colonial Office fund the erection of a mosquito-proof hut in the Campagna. This was occupied between July and October 1899, by two British and two Italian scientists. They remained healthy, compared with the fever-stricken peasants who had been unprotected. Subsequently, in London, Manson infected his son and a laboratory assistant with *Plasmodium vivax*-infected anophelines sent from Italy, thus conclusively demonstrating the vector-borne nature of malaria (Foster, 1965).

Grassi described the development of *Plasmodium falciparum, P. vivax* and *P. malariae* in his classic monograph published in 1900, but was hotly accused by Ross of pirating his discoveries. Ross accumulated testimonials from correspondents in Italy, and had them privately printed in Britain in 1900. These were circulated among friends as *Letters from Rome on the New Discoveries in Malaria*. Such letters included allegations that Grassi was a rogue and a robber in scientific domains, and that he and Italian collaborators had ignored important details of Ross's published work, and had invented their first infection experiments in Rome (Laird, 1998). Modern historians hold that Grassi and Celli acknowledged Ross's proof of the transmission of avian malaria. It was the Italians, however, who applied Ross's discoveries to human malaria. Nevertheless, Ross's '*Letters from Rome* [...]' helped persuade the Nobel Prize Committee to award the Nobel Prize in Medicine for 1902, to Ross alone (Laird, 1998). In 1911 Ross was created a Knight Commander of Bath (KCB) for his services to medical science.

ENDNOTES

1. Sir Charles Martin was highly respected in Australian medical and academic circles. He first came to Australia from England in 1890, as a demonstrator in Physiology at the University of Sydney. In 1897 he was appointed lecturer at the University of Melbourne, and in 1901 became Professor of Physiology. In 1903 he returned to England as Director of the Lister Institute of Preventive Medicine in London, revisiting Australia in 1924. After his retirement from the Lister Institute, he was appointed Chief of CSIR (later to become CSIRO) Division of Animal Nutrition for the period 1930–1933, concurrently serving as Professor of Physiology and Biochemistry at the University of Adelaide. Following his return to England in 1933, he conducted some preliminary investigations for CSIR on myxomatosis in rabbits. (extracted from the *Australian Veterinary Journal Annual Conference Handbook,* Melbourne, May 1970, p. 28).

2. The Faculty of Medicine was established at the University of Queensland in 1936.

3. Leptospirosis is a contagious disease of animals and man, caused by an infection of spirochaetes (*Leptospira* spp.). Although once thought to be protozoans, they are now considered to be bacteria of the family Treponemataceae. The typical mode of infection is from contact with urine, or urine-contaminated feed or water.

4. The Commonwealth Government appointed a Prickly Pear Board in 1920 to investigate bio-control agents of *Opuntia* (prickly pear), a cactus brought to Australia from North and South America in the 19th century as a garden plant. It spread from gardens until it occupied 100,000 square miles of land, rendering pasture unusable for grazing or crops. Over a thirteen year period, Australian biologists sent a variety of insects back from America, finally achieving control in 1925 with the larval form of a moth, *Cactoblastis cactorum*, from Argentina.

5. Forerunners of the Commonwealth Scientific & Industrial Research Organisation (CSIRO) were the Council for Science & Industry founded in 1919, which in 1926 became the Council for Scientific and Industrial Research. It was not until 1949 that the name of the organisation was altered to its current title.

6. William Tyson Kendall (1851–1936) arrived in Melbourne from England late in 1880. In January 1888 he established a privately owned Melbourne Veterinary College on assurance from the Victorian Government that his graduates would gain full recognition. The Melbourne Veterinary College was the first veterinary school in any English-speaking country to provide a longer four year course. Although the College was successful, limited finance and Kendall's advancing age necessitated its absorption into the University of Melbourne in 1908. This institution conferred on Kendall an honorary degree of Doctor of Veterinary Science. He remained on the university staff as Lecturer in Veterinary Medicine until 1923. (*Australian Veterinary Journal Annual Conference*

Handbook, May 1970, pp. 27–28).

7. The Stock Experiment Station at Yeerongpilly became the Animal Health Station in 1933 and was renamed the Animal Research Institute in 1953.

8. This situation is analagous to the pathological effects wrought by the rat lungworm *Angiostrongylus cantonensis* when it enters the wrong host. In its definitive host, the rat, the larvae migrate to the brain where they grow, moulting to become adults. The adults then migrate via the meningeal veins to the right heart, and thence to the lungs. In the wrong host, however, the worm's migration to its preferred site is blocked by incorrect physiological stimuli, and the larvae cause extensive damage to the brain and meninges, leading to eosinophilic meningoencephalitis. Drs M.J. Mackerras and D.F. Sandars working at the Queensland Institute of Medical Research in the 1950s, reported the life cycle of what they thought to be *A. cantonensis*. However in the early 1970s a PhD candidate, Manoon Bhaibulaya at the University of Queensland, demonstrated through morphological, life cycle and cross-transmission studies, that the parasite was in fact a new species, which he named *Angiostrongylus mackerrasae*.

9. Ocular infections of humans by canine parasites are not uncommon. A Brisbane ophthalmologist, Dr L.J. Pigott, advised the senior author, some 27 years ago, of having witnessed the removal of an adult female *Dirofilaria immitis* (canine heartworm) from the anterior chamber of a male patient's eye at the Princess Alexandra Hospital in Brisbane.

10. The previous editor, Dr Greg Berry, was a former student of Sprent, and had collaborated with Cannon on the life cycle of *Sulcascaris sulcata*, an ascaridoid nematode adversely affecting the scallop industry. Berry & Cannon (1981) demonstrated the worms matured in marine turtles.

11. The Harold W. Manter Laboratory of Parasitology was established in 1971 at the University of Nebraska, and serves as a national resource center for animal parasitology. The late Dr Manter's collection formed the nucleus of the new collection. Major additions to follow were the collections of Drs Solomon L. Loewen, J. Teague Self (helminths) and Franklin Songandares-Bernal, and the University of Minnesota parasite collection (helminths). The focus is on animal parasites of animals and man, with some primary strength in digenean trematodes, but other helminthes and some protozoans are represented.

12. According to Sir Macfarlane Burnet, who was awarded the Nobel Prize for his Clonal Selection Theory in immunology, modern immunology dates from 1955. Burnet reasoned that 1955 was the year that the Salk vaccine against polio came into general use, and this marked the effective conquest of infectious disease — immunisation against smallpox, diphtheria, whooping cough, yellow fever and tetanus having been in regular use for many years.

13. The inclusion of a bacterial pathogen was important, since the foundation of knowledge of immunity had been laid mostly in relation to bacterial infections. Knowledge about immunity in parasitic infections caused by protozoa, helminthes and arthropods, received considerable impetus from the publication of *The immunity of Parasitic Infections*, written by W.H. Taliaferro in 1929 (Sprent, 1969c).

14. While visiting the Young's, Cannon met John Bull, an engineer who was to become the husband of Dr Mary Beverley-Burton, a colleague of Young's at the Commonwealth Bureau of Helminthology, St Albans. She had just flown to Canada in pursuit of her children taken there by her estranged husband, Dr David Mettrick of the Zoology Dept., University of Toronto. Cannon's future wife, Christine Deane, was to become a student of Mettrick. Beverley-Burton later found a position at the University of Guelph (in the same department as Roy Anderson). The University of Guelph at one time was home to R.J.G. Lester who took over marine parasitology from Cannon at the University of Queensland. Leslie Newman who gained a PhD from the University of Queensland, collaborated extensively with Cannon on studies of polyclad turbellarians. Networking between Canada and Queensland was perpetuated by Leslie Chisholm, Mary Beverley-Burton's technician who came to do a PhD with Whittington at the University of Queensland, and who subsequently stayed on to pursue post-doctoral research in collaboration with Whittington, and subsequently in Adelaide.

15. Herbert Womersley (1889–1962) was a world authority on the Order Acarina. He became an entomologist at the South Australian Museum in 1933, and initially concentrated on the taxonomy of the Apterygota resulting in his publication *Primitive Insects of South Australia* in 1939. However in 1933 he discovered that the Order Acarina was largely unstudied, and published two short papers on that Order. Increasingly, his attention focussed on collections of free-living and parasitic mites, and he was bombarded with requests for identification. In 1952, Womersley published a monograph on trombiculid mites of the Oriental and Australasian regions, and included the immense collections that had been sent him from field workers, especially teams studying the epidemiology of scrub typhus [*Rickettsia tsutsugamushi*] over the Austro-Asian area. For many years his work remained the most complete account of the trombiculid mite fauna of this region. Herbert Womersley was born in Warrington, Lancashire, England. He was trained as an industrial chemist and had no formal training in entomology, though his father, as an enthusiastic amateur lepidopterist, had imbued the young Herbert with an early interest in Lepidoptera and Diptera. Receiving training in microscopy from Abraham

Flatters in Manchester, Womersley was able in 1920 to expand his entomological studies in Bristol by joining the Naturalists' Society. Subsequently becoming its president, he promoted the formation of the South-Western Union of Naturalists, and became secretary from its inception until he left England in 1930. By this time he had become a leading British authority on the Apterygota, especially the Collembola and Protura.

Womersley came to Australia in 1930 when he was appointed to the Council for Science & Industry's (CSIR) (the forerunner of the Commonwealth Scientific & Industrial Research Organisation, CSIRO) Division of Pasture and Field Pests. Following appointment he undertook induction and training periods at the British Museum of Natural History in London, and also in laboratories in South Africa, before taking up his CSIR appointment in Western Australia. Here his research assignments were to develop control methods for two pasture pests, the lucerne flea *Sminthurus viridis* and the red-legged earth mite *Halotydeus destructor*. His biocontrol measures using predatory bdellid mites gave promising results, but he was hampered by financial stringency. This prompted his resignation in 1933, to take up appointment as the entomologist at the South Australian Museum. He retired in 1954 but was immediately re-appointed as an acarologist at a salaried position created especially for him. Retiring at the age of 70 in 1959, he became an honorary, and increasingly devoted his research to the comparatively neglected Mesostigmata (Southcott, R.V. (1965) Obituary. Herbert Womersley. 1889–1962. *Transactions of the Royal Society of South Australia*, pp. 249–252).

16. The Australian Biological Resources Study (ABRS) is a program of the Biodiversity Group, Environment Australia. The aim of the ABRS is to provide the underlying taxonomic knowledge necessary for the conservation and sustainable use of Australia's biodiversity.

17. Lord Taylor was the Englishman who set up Medicare in England and also in Saskatchewan, Canada.

18. A stabilate is a bank of parasitic material of known immunogenicity, attenuation and transmissibility, used for inoculation.

19. Haemozoin is the malarial pigment whose origins are thus: on introduction to the blood of the new host, malarial sporozoites circulate briefly and then invade liver cells in the 'pre-erythrocytic cycle'. This comprises the incubation period of malaria before the parasites enter the blood and evoke the classic manifestation of fever and chills. Incubation periods for the four human Plasmodia are: *Plasmodium falciparum* 8–20 days; *P. vivax* 12–15 days; *P. ovale* 16–18 days and *P. malariae* 24 days. Within the liver the sporozoites change into forms that cause the liver cells to rupture, and thus the parasites invade red blood cells. Within the red blood cells, the parasite ingests haemoglobin and converts the haeme portion to the malaria pigment called haemozoin.

20. The systematics of mosquitoes were not well known at the time of Ross' experiments, so he had no English language publications to refer to for the morphological differences of mosquito genera. Although the genus *Culex* was described in 1758, and the genus *Anopheles* in 1818, accurate English descriptions of them were unavailable.

21. In his book *Malaria Parasites and Other Haemosporidia*, Garnham (1966) commented on the leading role of bird malaria parasites, notably *Plasmodium relictum*, in the development of malaricidal drugs.

22. Professor Percy Cyril Claude Garnham (1901–1994) was acclaimed on his 90th birthday as the 'greatest living parasitologist'. A graduate of Bart's Hospital Medical School in 1925, he served in the Colonial Medical Service in Kenya for 21 years, where he became the first director of the Division of Insect Borne Diseases, and worked on onchocerciasis, plague, relapsing fever and malaria. From 1947–1968, Dr Garnham served on the faculty of the London School of Hygiene and Tropical Medicine (LSHTM) as Reader, and later Professor. On his retirement from the LSHTM he was appointed Senior Research Fellow at the Imperial College, where he remained for the next 12 years. Dubbed by some as 'Mr Malaria', Garnham will be best remembered for the co-discovery of the hypnozoite, the malaria stage that remains hidden from the time a patient is bitten by a mosquito until the peripheral red blood cell is invaded. In a series of experiments with Professor H.E. Shortt, he demonstrated the hypnozoite form first in monkeys, and eventually in human volunteers. In concordance with his philosophy that it was impossible to be a true parasitologist if one were limited to the few which caused human disease, he amassed a unique collection of nearly 200 species of malaria parasites of man, mammals, birds and reptiles. Prof. Garnham was a Fellow of the Royal Society (FRS), and in 1964 had bestowed on him the imperial honour, the Commander of St Michael & St George (CMG) in recognition of his services to science. He was one of the first Fogarty International Scholars at the National Institutes of Health in Bethesda. (Extracts of an obituary by Professor R. Killick-Kendrick, Imperial College, Silwood Park, reprinted in the 12 January 1995 issue of *The Independent* newspaper, London).

23. The World Health Organisation has, for many years, conducted research into the bio-ecology of *Simulium damnosum* and *S. naevi* as vectors of 'river blindness' caused by the filarioid *Onchocerca volvulus*. The microfilariae of this parasite may invade the cornea causing sclerosing keratitis, or migrate into the vicinity of the optic nerve, retina

and choroid, with resultant irreversible blindness. *Onchocerca volvulus* is responsible for causing blindness in African populations throughout tropical Africa: East & West Africa and the Congo Basin. *Onchocerca volvulus* also occurs in the tropical Americas (Mexico, Guatemala, Venezuala, Colombia and Surinam), where it is called Robles' disease. In the Americas it is transmitted by a different vector, *Simulium ochracaeum*, and is immunologically distinct from its African counterpart.

24. See Endnote 26.

25. Paul Ehrlich (1854–1915) was awarded the Nobel Prize in 1908 for his side-chain theory of antibody synthesis, which represented a quantum leap in the field of immunology; and for his work in chemotherapy. His early career between 1891 and 1896 was spent in Robert Koch's Institute for Infectious Diseases in Berlin, where he perfected histology staining techniques (histochemistry) and collaborated with Emil von Behring in the formulation of an anti-toxin against diphtheria (Brock, 1988). Ehrlich worked out a precise method of measuring the potency of anti-toxins for diphtheria in units which related to a fixed standard. This was the first biological standard ever developed. Ehrlich's research in the field of chemotherapy was based on the various chemicals' affinity for tissue, and the action of chemical compounds on the body's cells, as well as on disease-causing organisms such as parasites. Ehrlich named these affinities 'organotropic' and 'parasitotropic'. He investigated ways to produce chemical compounds that were maximally 'parasitotropic' to kill the invading parasite and minimally 'organotropic' so that the least damage was done to host tissue (Marquardt, 1949). Ehrlich reasoned that protozoan diseases such as malaria and trypanosomiasis which did not respond to 'serum therapy' [immunisation] must employ chemotherapy to kill the parasites. His invention of 'trypan red' against trypanosomiasis arose from his observation that benzopurpurines remain a long time in the organism. However, that substance exerted only a weak effect on trypanosomes. Increasing its solubility with the addition of the sulfuric acid group, he formulated 'trypan red', a red Benzedine dye which was effective against trypanosome infections in both animals and man. Ehrlich's work from 1906 until his death in 1915, was mainly dedicated to developing chemical compounds which would act as specific curatives for human parasitic diseases by aiming exclusively at the parasite (Marquardt, 1949).

26. Rohde spent six months in Khartoum, Sudan, as Associate Professor of Zoology, but when it became apparent he would not be appointed Head of Department, he returned to Australia to become Director of Heron Island Research Station.

27. The Colliver Scholarship was a scholarship established by the Queensland Museum in memory of Frederick Stanley Colliver (1908–1991), described as being 'an exceptionally versatile and dedicated field naturalist'. An amateur geologist, paleontologist and anthropologist, Colliver's chief interests were rocks, minerals, fossils and mollusc shells in each of which he built up an immense private collection. Between 1931 and 1948 he was an active member of the Victorian Field Naturalists' Club, only resigning to become Curator of the geological collections in the Department of Geology at the University of Queensland. In Queensland he became a member of the Queensland Naturalists' Club in 1948, was elected to Council in 1949 and was Club President 1951–52, thereafter serving as a Councillor or as Librarian for the Club. For many years he was librarian to the Royal Society of Queensland, and also of the Great Barrier Reef Committee. He was responsible for the continuation of the Anthropological Society of Queensland, and was Section Secretary for Anthropology at three ANZAAS meetings in Brisbane. His work and interests brought him into frequent contact with the various sections of the Queensland Museum, and he became President of the Museum Society of Queensland in the late 1970s. In this capacity he organised a team of volunteers to assist the collections and educational services of the Museum, and in 1986 was awarded one of the inaugural Queensland Museum Medals for services to the Museum and to the natural sciences. The previous year he was awarded the Order of the British Empire (OBE) for services to natural sciences. In 1990 he became an inaugural Fellow of the Royal Society of Queensland for services to the Society. In acknowledgment of his contributions to the many societies to which he had donated his time and knowledge, in June 1992 the inaugural Stan Colliver Memorial Lecture was organised by the Royal Society of Queensland, the Queensland Museum Society, and the Queensland Branch of the Geological Society of Australia. On his death, some 200,000 fossils numbering were presented to the Museum of Victoria; and 400,000 mollusc shells, 5,000 geological specimens, and numerous anthropological artefacts, were donated to the Queensland Museum. All items in these various collections were meticulously labelled and indexed. The Queensland Museum was also given his extensive library of books and journals.

28. Aquaria and aquatic animals were a popular late Victorian interest in England.

29. David Molyneux is now Dean of the School of Tropical Medicine in Liverpool, England.

30. Sprent's association with Tiner began in relation to Tiner's studying the life history of *Ascaris columnaris*, whilst Sprent was comparing its migratory behaviour in the white mouse with that of other *Ascaris* spp. They maintained correspondence for many years and on occasion, because of their then mutual research interests, Tiner presented papers of Sprent's at conferences which he himself

was unable to attend. In a letter written in 1972 as a personal reference, Sprent made the following observations: 'I can say without hesitation, that Dr Tiner's publications on the significance of encapsulated larvae of certain species of ascaridoid nematodes revealed that he had a rare insight as an investigator and, moreover, the work turned out to be of the utmost significance in relation to the helminth zoonoses. I have been investigating this group of nematodes for many years and at one time Dr Tiner and I shared a mutual interest in the migratory behaviour of their larvae [...].Tiner's work constituted an unchallenged priority in this field. [It was] Rudolph Leuckart in the middle of the nineteenth century [who] maintained that the life history of the ascaridoids required an intermediate host. He held this view mainly because he had observed encapsulated ascaridoid larvae in the tissues of small mammals. Nevertheless, for almost a century his views had been eclipsed by the discovery of the tracheal migration exhibited by the larvae of *Ascaris suum*. It was Tiner's work, first published in 1949, which stimulated a subsequent reassessment which showed that, for most of the ascaridoids, Leuckart's views were correct.'

31. The Clonal Selection Theory postulates that the lymphoid cells bear on their surfaces, specific epitopes, or antigen-combining sites. Each primitive cell bears a pattern which becomes characteristic for the clone of cells to which this cell gives origin. Animals do not produce antibodies against antigens comprising their own tissues and fluids because contact of these cells during embryonic life with the corresponding antigen, leads to destruction of the cells and obliteration of the pattern. Thus, an antigen to which an animal is exposed during embryonic life ceases to be antigenic because this particular animal henceforth lacks the corresponding combining site. This animal thereafter becomes tolerant to this antigen — a state called 'immunological tolerance'.

32. The genus *Krefftascaris* is named after Gerard Krefft, erstwhile Curator and Secretary of the Australian Museum in Sydney, '[...] who listed but did not describe, a species of *Ascaris* from a freshwater tortoise, *Elsaya dentata*, from "Northern Rivers" of Australia'. Gerard Krefft (1830–1881) was a German emigrant who developed his interest in natural history in Australia, and became a recognised authority on Australian snakes and vertebrates. For thirteen years he was Curator of the Australian Museum, Sydney. He corresponded with Charles Darwin, proselytized Darwin's theory in Sydney newspapers, and sent Darwin much corroborative data [...] on the behaviour and emotions of animals. Darwin thought well of Krefft and knew his writings [...] Krefft published a series of monographs and papers on Australian extinct and living mammals, as well as on birds, snakes, fish and whales, which brought him recognition from scientists abroad. (Ann Mozley Moyal, *Scientists in Nineteenth Century Australia. A documentary history*. (Stanmore, NSW: Cassell Australia Ltd., 1976)). Krefft's book, *The snakes of Australia. An illustrated and descriptive catalogue of all the known species*, originally published in 1869, was reprinted in Brisbane in 1984.

33. Record of Fellowships and Awards supplied to senior author as Protocol Officer during Brisbane's hosting of the Sixth International Congress of Parasitology, August 1986.

34. At Deception Bay, Young was acquainted with the existence of a naturally hollowed out area in the rock on the beach front, which was known as 'Mrs Bancroft's bath'. This would have been Mrs Thomas (T.L.) Bancroft, since Thomas Bancroft and his family lived at Deception Bay for many years.

35. Protogyny applies to hermaphroditic plants and animals in which female gametes mature and are shed before male gametes.